Appendix D—SR-94 wildlife crossing and highway expansion (SIMBA 2013)

SR-94 WILDLIFE CROSSING AND HIGHWAY EXPANSION

12/6/2013

100% Design Submittal

Project Manager-Brian Tran [Environmental]
Daniel Nouri [Structural]
Jecelyn Carranza [Construction]
Frank Shamas [Hydraulics]
Matthew Balan [Transportation]

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SR-94 Wildlife Crossing and Highway Expansion

Introduction:

Recent dramatic increases in urban, highway, and road development have increased interactions with wildlife and led to fragmented habitat. Inadequate size, poor design, poor placement, and insufficient availability result in limited use or avoidance of culverts by wildlife and fish. Since hydrological structures may not be adequate, crossing structures developed specifically for wildlife passage are now being incorporated into roadway designs. Projects currently in the planning stages are now being developed to provide for drainage as well as fish passage and wildlife movement. Employing multiple-use designs allows planners proactively employ comprehensive strategies that incorporate watershed integrity, habitat connectivity, and provide cost savings by decreasing collisions, injuries to humans, and damage to vehicles. [1]

Executive Summary:

The purpose of this project is to address the issue of habitat connectivity and wildlife crossing State Route 94 safely in an area north of the city of Jamul. It is little to no surprise that road and highway developments have a large impact on natural habitats and wildlife. State Route 94 is no exception, dividing the north side from the south side of the San Diego National Wildlife Refuge. Too often, animals attempt to cross the highway and end up endangering not only themselves but human motorist as well. The fundamental basis of this project includes designing a culvert that will ideally serve all different species in the area, effectively decreasing the mortality rate of wildlife and increasing safety for motorist. This project will also include widening of SR-94 to have a LOS A by determining how many more lanes will be needed to service traffic flow in future years. Additional considerations are the local watershed welfare and major pipelines from the Otay Water District pump station that will need to be avoided or redirected at the discretion of the water consultant. While all this is underway, construction management will address construction access, budgeting, and phasing of the project as to not congest traffic during working hours. The wildlife-crossing project must also keep in mind to minimize environmental impact, especially due to the nature of the wildlife refuge.

Assumptions/Constraints

Certain assumptions and constraints must be made.

Assumptions	Constraints
Wildlife movement corridor – Access to wildlife movement cameras were limited.	Monitoring equipment and data – Monitoring Equipment too expensive to buy and use.
Width of highway after expansion – Used typical widths of highway roads	Lack of soil information – USGS does not have soil data for particular region
Depth of Creek – Unable to properly measure depth of creek.	Watershed data – Unable to find various watershed data
Peak hour direction slip traffic data – Data unavailable from traffic count	Highway Cross-section data – Cross-sectional area data cost money to view
Relative cost – Impossible to find accurate prices of items	Unable to acquire data until design phase – Time constraint

Management Scope:

Figure 1.1 shown below describes the management scope and steps to take in planning, implementation, and adaptive management when designing a wildlife culvert.

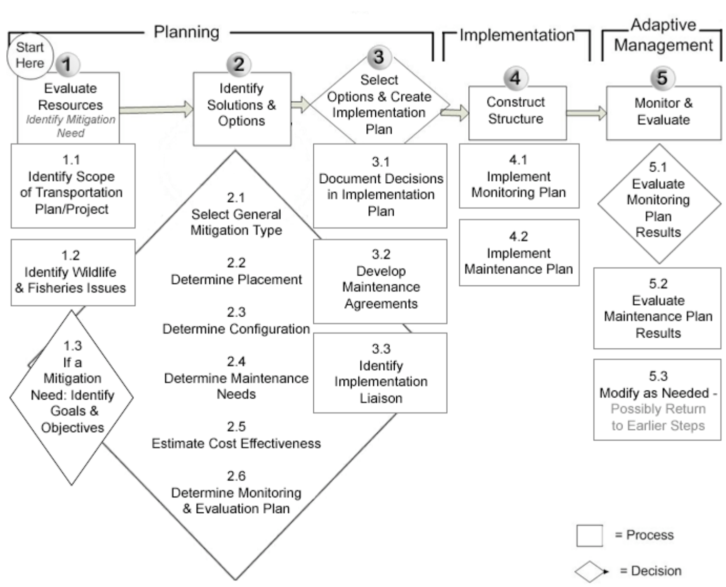


FIGURE 1. 1

Environmental

Background:

To help better understand the interactions between roads and environment the discipline of road ecology has emerged in the last 10 years. Road ecology strives to understand surface transportation infrastructure and its impacts on wildlife and motorist safety, aquatic resources, habitat connectivity, and many other environmental values. Roads affect populations in numerous ways, from habitat loss and fragmentation, to barriers to animal movement, and wildlife mortality. The impact of roads on wildlife populations is a significant and growing problem worldwide.[2]

Figure 2.1 shown below represents the inversely proportional relationship between road density and wildlife density. As road density increases, wildlife populations diminish.

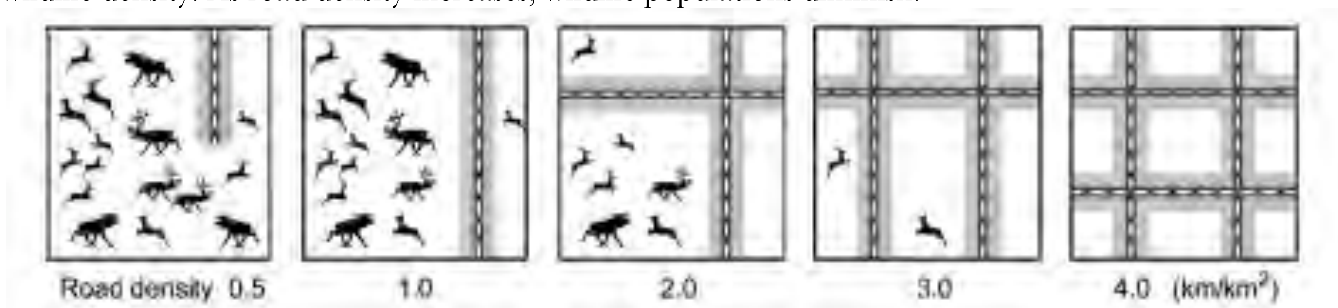


FIGURE 2. 1

Figure 2.2 shown below represents the barrier effect on wildlife populations. (A) Shows a healthy unaltered diverse population with subpopulations linked together through dispersal. (B) Shows the barrier effect of placing a road in a habitat thereby isolating populations.

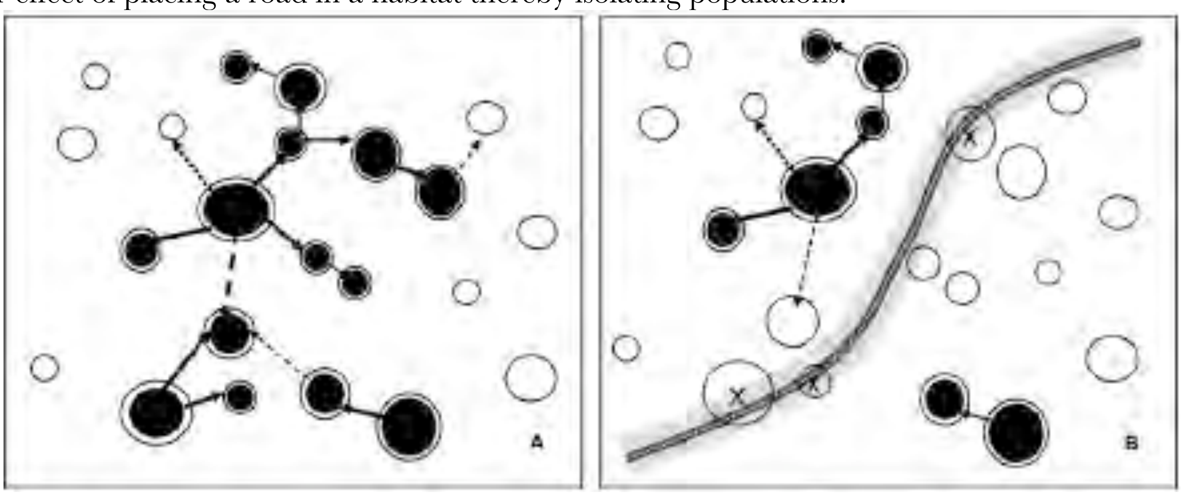


FIGURE 2. 2

Figure 2.3 shown below describes the effect traffic volume has on (1) animal avoidance of roads, (2) the likelihood of them getting killed while trying to cross, and (3) successful crossing attempts.

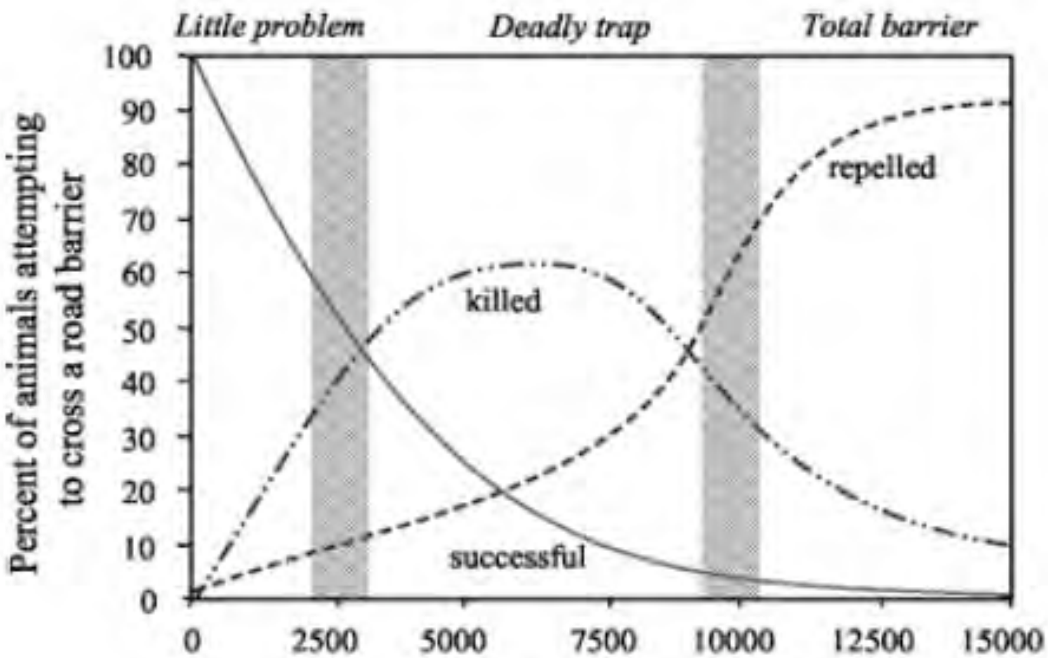


FIGURE 2. 3

Culvert Environmental Considerations:

When implementing a culvert, it is imperative to consider designs that offer the lowest impact to the surrounding environment. Along with federal and local regulations, certain environmental criteria must be met to ensure proper use of the culvert.

1. Identify species of concern species in the area such as threatened or endangered or any Species of Concern as defined by state or federal agencies, paying attention to those with special culvert needs.
    a. This can be done by monitoring fish and wildlife movements in the area to determine natural wildlife movement corridors, crossing areas, behaviors, and crossing frequency.
    b. This was also provided from client – mainly large animals
2. Determine number of culverts necessary to facilitate both water drainage and wildlife crossing.
3. Identify culvert shape and size requirements for the species in the area with special consideration to:
    a. Noise/sound
    b. Temperature
    c. Light/Viewable openings
    d. Moisture
    e. Entrance cover
    f. Nature/Artificial footings

4. Consider designs that enhance the overall appeal and attraction of culvert to accommodate various types of species.
5. Culverts should be durable and able to withstand high flow rates during peak rainfall seasons as well as buildup from dirt and debris.
6. Fencing designed to accommodate multiple species should be installed to prevent wildlife from reaching the road
7. Proper maintenance of culverts to ensure proper functionality including cleaning debris, repairing fencing issues, planting vegetation, and ensuring structural integrity.

Shown above is a picture of a bobcat using a medium-sized box culvert from the Florida Department of Transportation.

1. Species of concern typically range from large mammals such as mountain lions to small reptiles and rodents.
2. In this case, only one culvert will be implemented to ideally serve all animals in the region
3. As discussed in the next section, an openness ratio of 1.20 will be used for the culvert. An openness ratio value of 0.75 is the minimum require for large mammals, so the culvert is more than adequately sized for its purpose.
4. When placed, the bottom of the culvert will be covered with natural soil from the local area, this ensures animals are comfortable to utilize the culvert.
5. Discussed in the hydrology sections of this report, the culvert will be able to withstand high flow rates during peak rainfall seasons using a 100-year storm report.
6. Often times, fences are utilized to help promote and encourage wildlife to use underground culverts. Appropriate fencing is crucial to the success of a culvert because it funnels wildlife into the culvert and away from roads. Fences are embedded to a certain depth to restrict animals from digging underneath fences and crossing roads. When placing fencing, trees and large bushes should be taken into consideration because some animals tend to climb trees and can jump over the fence, rendering it useless.
7. With proper care and maintenance, the use of a culvert will last much longer.

Structural

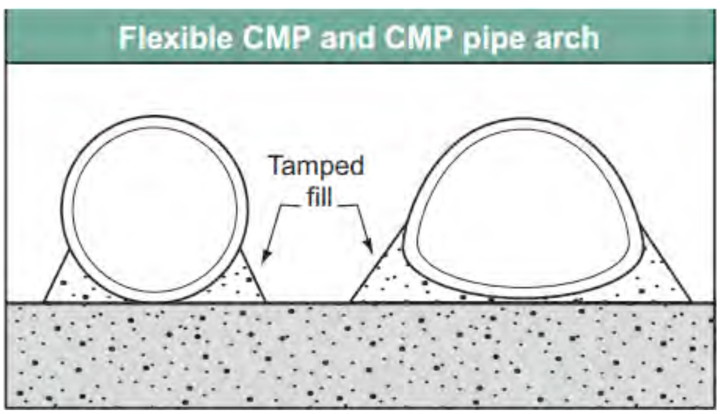
Introduction

The design of a wildlife culvert requires the consideration of a number of factors. These factors include the type of culvert, the likeliness that animals will use it, the stability of the soil, bearing capacity and foundation requirements, cast in place or precast structures, total loading, and concrete reinforcement.

Type of Culvert

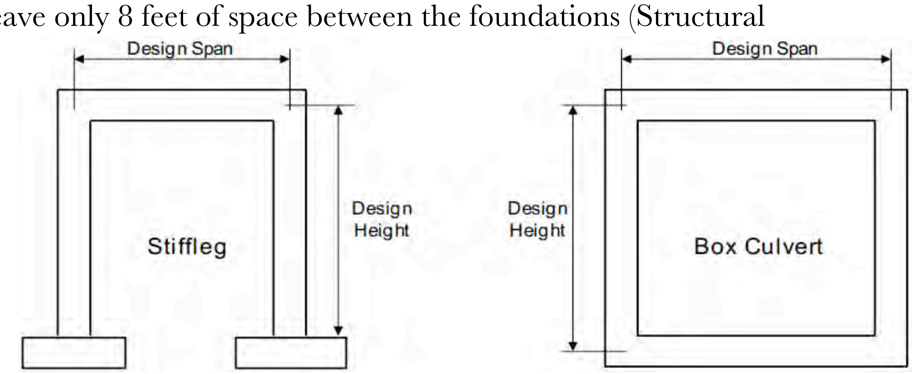
During the design process a number of culvert designs were considered. These included a corrugated metal pipe arch (CMP Arch), a 3-sided stiffleg culvert, and finally a precast concrete box culvert.

The idea to use a corrugated metal pipe arch was discarded because, while such a structure would have a relatively low materials and installation cost, it would not be suitable for the heavy soil and highway loading the culvert would be subjected to. The structure would easily flex under the heavy load, which would create significant problems for the highway above. It would also be impractical to create a natural channel bottom in such a structure. As a result, the bumpy metal pipe would offer inadequate footing for animals and the round shape would not seem spacious enough to encourage animal use.



The next design choice was a 3-sided stiffleg culvert. This option would eliminate the issues of the corrugated metal pipe. The design would be strong enough to support the soil and highway loads while allowing for a natural channel bottom. The square design would also allow for a greater span width and would be much more inviting to passing wildlife. While the initial material and installation costs would be greater than those of the CMP Arch, the lifetime of the concrete culvert would be significantly longer.

This design was to be supported by strip footings, which would run the length of the culvert. When calculating bearing capacity of the soil and the associated width of the strip footings it became apparent that the width of the footing would leave only 8 feet of space between the foundations (Structural Appendix). As a result it was decided that a concrete box culvert would be more practical. By extending the base 3 feet deeper into the ground and filling the culvert until 12 feet of clearance is available all of the requirements for the culvert would be satisfied.



Ease of maintenance is another

benefit of this design. By creating a wide open and easily accessible pathway maintenance workers can easily traverse the length of the passage and remove any debris that might accumulate.

Openness Ratio

The determination of a wildlife culvert's size is based on the size of animals that will utilize the structure as well as the width of the road under which the culvert will pass. The width of the road corresponds to the length of the culvert. To encourage animals to use the structure, they must be able to have a clear field of view from the entrance to the exit, therefore, as the culvert length increases so must the cross sectional area. The 'openness ratio' is a relationship which factors in the dimensions of the culvert and provides a ratio that determines suitability for animals of a certain size whereby [1]:

$$\text{Openness Ratio} = (\text{Culvert Height x Culvert Width}) / \text{Culvert Length}$$

Large mammals require a height of at least 6 feet and an openness ratio of at least 0.75, although 0.90 is prefered. In order to encourage the use of the culvert by large mammalian fauna an openness ratio of no less than 1.20 will be used for this project. Visible in Structural Appendix are calculations regarding the openness ratio for a CMP and for a box culvert. Based on client needs, a three sided stiffleg culvert was designed with 80 feet length, 12 feet height, and 22 feet span width which provides an openness ratio of 3.3. The 80 foot width is based on the lane width for the highway expansion. Supplemental calculations in Structural Appendix provide openness ratio calculations and basic assumptions used during the design process.

Foundation Requirements

Soil data for the project site was not readily available and as such it was necessary to make assumptions regarding the soil type based on site visit observations and available data for sites with similar soil characteristics.

By using San Diego County Recon Survey data for the Jamul Mountains it was a safe assumption to make that the soil type is a San Miguel-Exchequer rocky silt loam. When the 3-sided stiffleg structure was being considered it was necessary to calculate the bearing capacity of the strip footings that were to run along the length of the culvert. Terzaghi's Bearing Capacity Theory was used to find the ultimate bearing capacity and the width of the footing. These calculations are available in the Structural Appendix a graph of the footing width compared to the total bearing capacity. Once these calculations were complete the decision was made to change the design to a box culvert.

Cast in Place or Precast Design

Cast in place and precast culvert designs offer unique characteristics and are chosen based on the needs of the project. Based on AASHTO LRFD Bridge Design Specifications Class 40A concrete and Grade 60 reinforcement are required for this design.

A cast in place design would require adequate time to place the reinforcement, prepare the molds, pour the concrete, and allow the concrete to cure. This would be difficult due to the need for a staging area to store extra materials and concrete trucks. On site concrete testing would also increase costs and time. Weather would also have to be optimal for pouring the concrete.

A precast design would allow for completion of the culvert on the same day that the trench is excavated. A precast design would still require a staging area for the precast segments to be stored. Various trenchless technologies for culvert installation are available and would allow for cheaper and significantly faster culvert installation while minimizing the need for closures of the road above.

This method would be advantageous when compared to a cast in place design due to the elimination of a number of factors, which include errors in pouring, on site sample testing, and concrete curing in the truck. It would also decrease construction time by eliminating the need to place molds and reinforcement prior to pouring.

For the reasons listed above it was decided that a precast design would be the most practical and economically feasible choice.

Total Loading

The various loads on the culvert were determined by following design standards in the Federal Highway Administration IP-83-6 design manual. The loads calculated in this section include culvert weight, fluid loads, live loads, unexpected loads, and earth loads which are verified by determining distribution of earth pressures.

<u>Culvert Weight</u>

Approximate culvert weight can be calculated using an equation in the Structural Appendix. This formula is provided by the FHWA; however, it is more appropriate to use culvert weight tables provided by the American Concrete Association Pipe Design Handbook. These resources estimate the weight of the culvert to be approximately 100 kips per square foot, which is approximately equal to 700 pounds per square foot.

Earth Loads & Distribution of Earth Pressures
Earth loads were calculated in kips per square foot using an equation from the Structural Appendix. This formula, which was provided by the FHWA yielded results of approximately 36 kips per square foot (250 pounds per square foot) from soil pressure on the top of the culvert. This value was verified by checking the distribution of earth pressures using FHWA supplied equations.

Fluid Loads
Due to the natural channel bottom and the minimal flow that will be present in the culvert it is not necessary to consider fluid loads.

Live Loads
Due to the depth of the culvert transient loads will not have any significant impact. Instead loads will be added to simulate loading from stopped traffic on the highway above.

Unexpected Loads
To account for unanticipated loading on the culvert a surcharge of 2 feet of 120 pound per cubic foot soil is added to the load. This summation equals approximately 250 pounds per square inch and simulates stopped vehicles on the highway above the culvert.

Total Loading
The total loading summed up to approximately 1200 psi. During design, all calculations were rounded up in order to add a factor of safety. It is unlikely that there will be loads exceeding what have been calculated.

Concrete Reinforcement

By using design guidelines provided by the American Concrete Institute Committee 314 it was possible to calculate the required reinforcement in the concrete culvert. By calculating self weight, ultimate and nominal moments, and the reinforcement ratio it was determined that 2 rows of 4 #7 steel bars spaced approximately 3.8 inches apart with two #5 stirrup bars would be sufficient to support the load on the culvert. These calculations and a representative cross section are available in Structural Appendix.

Additional Considerations

As visible on the Structural Appendix it will be important to add flared wingwalls to the opening of the culvert. These wingwalls will hold up the earth surrounding the culvert in the event of a flood or storm and will prevent soil failures that would result in landslides. The wingwalls will need to extend almost perpendicular to the opening for 6-10 feet with a gradual slope. The pressures on these wingwalls will not be significant enough to cause failure. They are simply in place to prevent erosion that could result in soil failure.

Hydrology

This design approach provides for the development of a natural streambed within the crossing structure, which is continuous with the upstream and downstream channel. The approach also provides a corresponding width and height of opening to ensure the long-term viability of the culvert. The SR-94 culvert is to have the following characteristics:

1. The culvert will allow proper flow through it as to not constrict or stop flow from the drainage basin.
2. Although the culvert will have a concrete floor, the bed material will be the same as the creek bed.
3. It provides for terrestrial passage of wildlife during "normal" flow conditions

Runoff

Runoff currently flows into nearby creeks that run adjacent to the highway. Since the majority of the creeks will be undisturbed runoff will continue to flow into these natural channels. There is one 10-yard stretch in which the highway widening intrudes on a creek. This can be remediated by excavating a new segment for the creek into the nearby hill. The runoff on the North side of the SR-94 will be diverted underneath the freeway through the culvert to the creek. The runoff that flows through the culvert, either from the highway or from the adjacent hills, will contain silt that can build up in the culvert. This buildup will only occur when the velocity of the flow is slow enough to deposit silt without eroding the soil that is present. Due to the cross sectional area of the culvert it is unlikely that enough buildup will occur to prevent the flow of water or use of the culvert by wildlife. Regardless of congestion by silt, the removal of plant detritus and other materials, such as litter, will require regular maintenance. During this maintenance, workers will be able to note the amount of congestion and level the soil if necessary.

Depending on the duration and velocity of flow that might occur, erosion of the natural bed in the culvert must be considered. Since flow will be diverted to the culvert it is likely that new creeks will form leading water through the new passage. This could create issues for the usability of the culvert for wildlife. This problem can be resolved through regular maintenance and inspections to insure the condition of the culvert lining.

Drainage Basin

The drainage Basin for the culvert was taken from USGS topography maps. The basin is only North of the SR-94. Any drainage south of the SR-94 collects in the stream running parallel to the road. The drainage basin for the culvert that collects North of the road is approximately 40 acres. With this area the flow is determined Q=CIA (.3)(3)(40)=36cfs

Culvert Flow

Many different flow conditions exist over time, but at a given time the flow is either governed by the inlet geometry or by a combination of the culvert inlet configuration, the characteristics of the barrel, and the tail water. Control may oscillate from inlet to outlet. While the culvert may operate more efficiently at times, it will never operate at a lower level of performance than calculated. The culvert design method used on this culvert is based on the use of design charts. These charts based on data from numerous hydraulic tests and on theoretical calculations.

Type of Control

The culvert in the design has a width of 22 feet and height of 12 feet. For this vast size the culvert will never be full when compared to the runoff of the drainage basin. In this condition neither the inlet nor the outlet end of the culvert are submerged. The flow passes through critical depth just downstream of the culvert entrance and the flow in the culvert is supercritical. The culvert flows partly full over its length, and the flow approaches normal depth at the outlet end. Since the control is at the upstream end in inlet control, only the headwater and the inlet configuration affect the culvert performance.

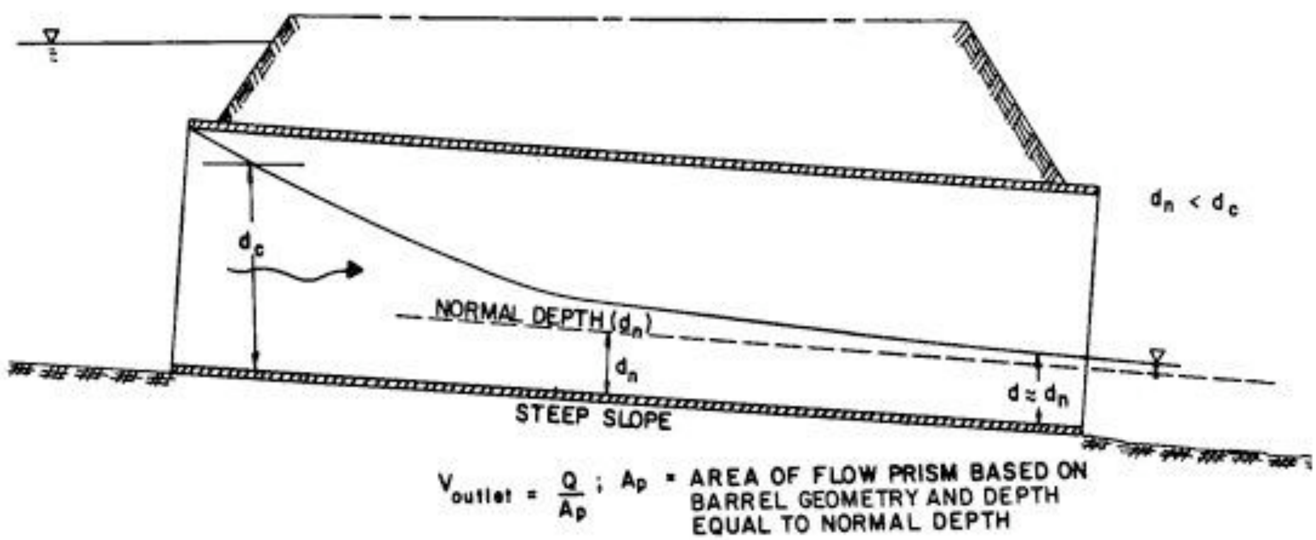
Roadway Overtopping

The results from the HY-8 concluded that in a 100-year event that there will be no roadway overtopping. Therefore the will be no design needed to satisfy an overtopping situation.

Outlet Velocity

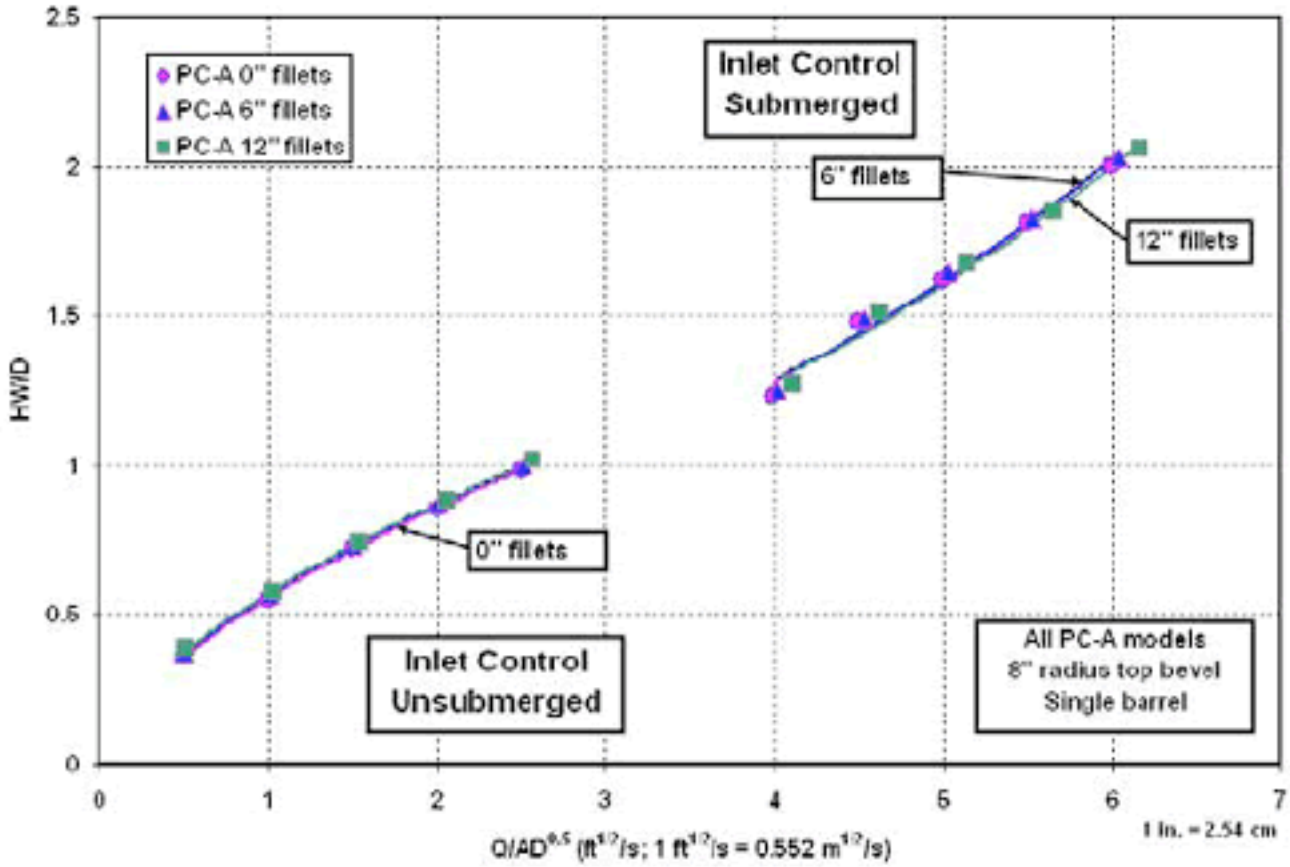
The outlet velocity of the culvert was determined by using the max volume of water for a 100 year event in HY-8 that equaled **27cfs/22ft=1.22ms**

The inlet control, backwater calculations are not needed to determine the outlet velocity because they are not critical as shown in the hydrology report. The critical depth of the culvert is .96ft



Performance Curve

The performance curve is represented by the flow rate versus headwater depth or elevation for the culvert. The performance curve was acquired from the use of HY-8. The performance curve for the culvert is shown below.



Erosion, Sedimentation, and Debris Control

Natural streams and manmade channels are subject to the forces of moving water. Sedimentation, erosion and debris flow happen naturally in flowing bodies of water. This process is accelerated during storm events when stream depths and velocities are high. Inserting a culvert into this natural flowing body will cause anyone of these problems.

Scouring

A culvert normally constricts the natural channel, thereby forcing the flow through a reduced opening. As the flow contracts, the velocity of the flow increases causing scouring at the embankments. To battle this, 10-foot winged walls will be use on both sides of the culvert. The winged walls inhibit scouring of the embankment.

Sedimentation

The companion problem to erosion is sedimentation. Most streams carry a sediment load and tend to deposit this load when their velocities decrease. Therefore, barrel slope and roughness are key indicators of potential problems at culvert sites. The SR-94 culvert will have a 22 foot by 6 inch sedimentation trap to eliminate sedimentation from filling the culvert. In high flows this trap will empty from the flowing water.

Debris Control

Debris along with sediment will be controlled with a sediment trap. The trap is to be the span of the culvert and have a 6” depth. For larger debris, the large width of the culvert will eliminate them from settling in the culvert

Site Pump

A pump is needed for the construction to divert water from the culvert location during seasonal precipitation. The pump must adequately divert all incoming flow around the new construction. The pump should be sufficient enough to handle a 20-year event during the construction phase.

Type of Pump

During a 20 year event the pump required must be capable of draining at least 4000gpm from the site an adequate pump must be comparable to the one below.

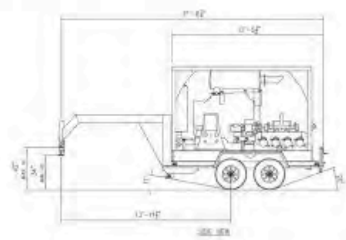
Dependapower DPPAT 4025 CAT-R Patterson/Caterpillar 4,000 GPM

Description:

The Dependapower DPPAT 4025 CAT-R is a trailer mounted, diesel driven horizontal split case centrifugal fire water pumping system. Nominal performance rating is 4,000 gpm @ 150 psi (10' lift). The pump and driver come mounted on a skid containing an integral 325 gallon fuel cell with level indicator. The easily detachable skid is transported on a dual-axle trailer. The 12" suction and 10" discharge headers provide minimal pressure loss for maximum efficiency. The 24VDC electrical system comes standard with two group-D batteries. Paint is basic red polyurethane finish on pump, skid and trailer. (*Not on Driver) Total Package Weight with Fuel = 15,000 lbs.

Trailer:

Gooseneck style dual axle 14,000 lb. GAWR trailer, complete with: electric brakes & coupler; DOT lighting package; 235/85 R16 LRF tires/wheels. Deck areas covered with safety "Grip" surface.



Pump Detail:

Manufacturer	Patterson
Series	MAA
Model	12 x 8 x 20.3
Fittings	Cast iron casting, Bronze trim, SS packing sleeve
Performance @	Shutoff 200 psi 4,000 gpm - 150 psi / 2,500 gpm - 175 psi
Priming	One 24 VDC Electric vane primer & reservoir

Driver Detail:

Manufacturer	Caterpillar
Model	3406-DITA
Power	500 BHP @ 2100 rpm
Electrical System	24 VDC
Cooling System	Radiator with pusher fan
*Paint	Standard base unit Caterpillar yellow

Suction Manifold:

12" diameter flange-fitted header furnished with: four (4) 6" (M) NH inlet connections, capped & one (1) 2.5" valved (F) NST swivel w/plug.

Discharge Manifold:

10" diameter flange-fitted header, furnished with: four (4) 5" storz discharge connections, capped, with gated discharge valves: (1) 2.5" (M) valved discharge connections.

Control Panel:

Includes: start/stop switch, tachometer, oil pressure gauge, coolant temperature gauge, amp meter, vernier throttle, compound suction gauge, discharge pressure gauge, fuel pressure gauge, primer valves & switches, hour meter.

Options:

Manual clutch between pump & driver
Four suction hose racks (passenger side only)
for use with 10' hoses only
SS Suction/Discharge Manifolds
Jet pump back-up primer
Automatic battery charger
Retractable awning over pump operator
6" NH hard suction hoses
(20' each - 4 req'd) or (10' each - 8 req'd)
6" NH "Light Weight" hard suction hoses
(20' each - 4 req'd) or
(10' each - 8 req'd)
6" Non-floating basket strainers (4 req'd)
6" Floating basket strainers (4 req'd)
Full skid cover
Add, 2.5" Discharge/Suction
4 Work Lights

Hydrology Report

This report is intended for the runoff and drainage study for the SR-94 culvert location and widening. The site is to be widened and have a new wildlife culvert added. The scope of this report is to show the current and proposed drainage system.

Brief Explanation of Site

The site is an un-urbanized wildlife area. There are many types of animals that need to cross the freeway both large and small. There is an existing culvert that is buried under sediment. The existing culvert is also much too small to adequately handle all the runoff to it.

Description Location

The site is located on the SR-94 approximately 3.2 miles east on SR-94 from the junction of campo road in Rancho San Diego. The site is a 2-lane freeway that travels in both directions. It is located in an un-urbanized area. The watershed comes from the North from primarily 2 hills that approximate to 30 acres.

Description existing structures

Currently there is a circular corrugated culvert hat is 3 feet in diameter at the location. Although this size would be sufficient for runoff, a sediment trap was not used therefore burying the culvert. The freeway has two lanes with no drainage. The runoff for the road goes into the nearby creeks. The road has a few utilities under it for water and sewage.

Description proposed structures

A new culvert will be put in place to replace the outdated corrugated culvert. The new culvert will also be a wildlife crossing for all animals in the area. The culvert is to be made of concrete and be a box shape. The size must be large enough to handle any large animals in the area. It must also be capable of handling the watershed and runoff. The freeway will be widened to 4 lanes after the culvert is put into place

Existing drainage

Currently there is no drainage collection system put in place for the road. The runoff currently distributes to the surrounding creeks.

Hydrology and Precipitation Analysis

The precipitation is shown for the area determined by the San Diego Hydrology manual. This is included in Appendix B

Computed project drainage basin

The rain intensity from the Hydrology manual in a 100-year event is 3in/hr shown in appendix B. The soil in the area is type C that has a c runoff coefficient equal to .3. The drainage basin area determined by USGS topography map is 40 acres. With that the max flow is Q=CIA

$$Q=(.3)(.3in/s)(40acres)=36cfs$$

Determine minimum culvert size for drainage

The minimum culvert size that can sustain a 100 year event will need to require 36cfs shown by Hy-8 in appendix C. The size for this would have to be approximately 9sqft determined by calculations and HY-8 shown in appendix. Since this culvert is also a wildlife crossing it is larger to handle the animals. The size determined for the crossing is 22' by 12', therefore the drainage is more than adequate for the culvert.

Computed maximum drainage available for future projects

With the data from the Hy-8 computation, a max flow for the culvert is determined. The max flow the culvert can handle is 1985cfs before overtopping. This allows for 90% expansion of the drainage basin for future projects that can handle more drainage.

Transportation

The highway expansion will occur along the State Route-94, between Steele Canyon Road and Honey Springs Road. Approximately 7.1 miles of roadway will be expanded. The entire length of the expansion will be increased from 2 lanes to 4.

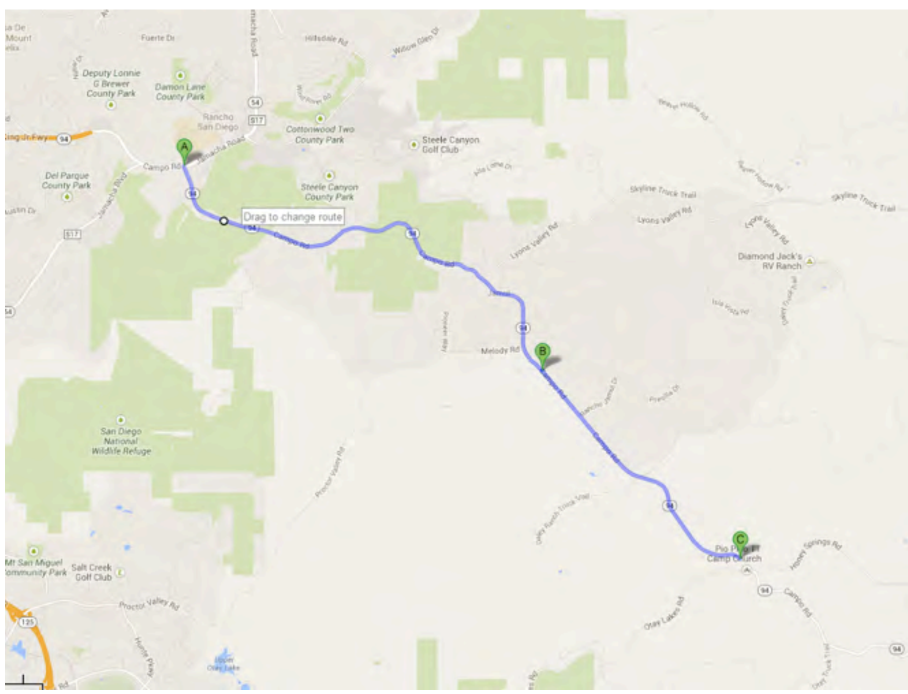
A Right of Way must be granted, since the high way expansion occurs on public land. Since the application process takes 60 or more days, it is assumed that all Right of Way is obtained, including tribal land.

Since no alterations were made to grading and additional lanes do not affect vertical curve calculations, it is safe to assume that the vertical curves for the existing road will remain the same for the highway expansion.

With an assumed design speed of 60 mph, the minimum radius of each curve is 1150 ft, designated by Table 203.2 in the HDM 200. The actual posted speed of SR-94 is 55 mph, 60 mph is assumed because 55 mph is not on Table 203.2 and can be considered a factor of safety. Based on this assumption, the super elevation for the highway expansion is the same as the 2 lane highway, 0.09.

Due to problems obtaining proper elevations, earthwork will be assumed and explained, in detail, in the Construction section of the project.

During excavation, lane sizes will be reduced to 10 feet each way. In order to accommodate for machinery that will be used during construction. As instructed by the HCM Table 5, the speed will be reduced by 6.4 mph for 10 feet lanes with 0-2 feet shoulders, resulting in an approximately 48 mph zone. This will be reduced to 45 mph. During the highway expansion, one-lane two-way traffic would be necessary to accommodate for lack of roadway available. Due to the length of the expansion, it may be necessary to stagger flaggers along highway in increments of less than 1 mile, as described in MUTCD Section 6C.



Construction

The SR-94 Wildlife Project entails adding box culverts to connect the San Diego Wildlife Refuge from the north side of the highway to the south side in order to reduce road kill. For the purpose of this project, only one large box culvert is being taken into account. Also, this project includes highway widening because plans show a casino being built in the Jamul area, which will eventually increase the traffic flow on the SR-94. Expansion will be for 10 miles, a change from the previously estimated 2 miles, and nearly all expenses are covered in the following page estimate.

Unit prices are found from the Caltrans site and quantity for the activity/item is an estimate (assumption) and pricing for the box culvert is from Jensen.

		Estimated Cost
I. Transportation Items	$	2470330
II. Structural Items	$	100000
III. Environmental Items	$	1181968
Total Project Cost	**$**	3752298

	month	year
Date (Month/Year) of Estimate	10/	2013

Section 1 Transportation

	item code	Description	unit	quantity		unit price	Cost
1	860090	Maintain Existing Traffic Management	LS	6	x	$ 865	$ 5190
2	120090	Construction Area Signs	LS	5	x	$ 5800	$ 29000
3	190101	Roadway Excavation	CY	1000	x	$ 225	$ 225000
4	194001	Structure Excavation	CY	670	x	$ 650	$ 435500

5	390129	Hot Mix Asphalt	TON	100	x	$ 146	$ 14600
6	260201	Class 2 Aggregate Base	CY	50	x	$ 40	$ 2000
7	374492	Asphaltic Emulsion (Polymer Modified)	TON	100	x	$ 1200	$ 120000
8	394090	Place Hot Mix Asphalt	SQYD	65	x	$ 200	$ 13000
9	066062A	COZEEP Expenses	LS	5	x	$ 160	$ 800
10	840656	Paint Traffic Strip	LF	25000	x	$ 1	$ 25000
11	128650	Portable Changeable Message Signs	EA	2	x	$ 3300	$ 6600
12	832001	Metal Beam Guard Railing	M	6420	x	$ 242	$ 1553640
13	39588	Guard Railing End Treatment	EA	16	x	$ 2500	$ 40000

Total Transportation Items	**$** 2470330

Definitions:

Maintain existing traffic is so that traffic flow will be sustained during construction hours.

Construction signs are to inform drivers of the ongoing construction.

Roadway excavation is to cut into the mountains in order to widen highway to desired width of 2 lanes for a total of 4 lanes. Pricing is based on how much cut.

Structure excavation is the cut needed to insert pre-engineered box culvert. Pricing based on how many cubic yards required to cut.

Hot mix asphalt is for the construction road. Pricing is based on how much needed in tons to expand the highway for 10 miles

Class 2 aggregate bases are needed to place the asphalt upon. Pricing based upon how much needed for 10 miles in cubic yards

Asphaltic emulsion is for surface treatment and is also based on tons for pricing.

Place hot mix asphalt is based on area in square yards for pricing.

COZEEP Expenses is so that police protects the workers.

Paint traffic strip is the alternating traffic strip and is based on linear feet for pricing.

Portable changeable message signs is so that it can inform drivers of any new information when construction changes in terms of phases and pricing is based on how many.

Metal beams guardrails is to protect the drivers from going off course or crashing into fixed objects. Pricing based on how many meters needed.

Section 2 Structural

Date of Estimate	11/30/13
Structure Type	Box Culvert
Width (FT)	20
Total Length	15
Total Area	19200
Structure Depth	64
Cost	100000

Total Structural Items	**$**	100000

Definition

Pricing of box culvert is from Jensen Precast, based upon its dimensions.

Section 3 Environmental

	item code	Description	unit	quantity		unit price($)	cost
	71325	Temporary Fence	LF	27900	x	26	$ 725400
1	20001	Highway Planting	LS	1	x	117690	$ 117690

2	201700	Exported Topsoil	CY	53	x	26	$	1378
3	203000	Erosion Control	SQYD	10	x	200	$	2000
4	21823	CHAIN LINK FENCE	M	6100	x	55	$	335500

Definition:

Temporary fence is to prohibit unauthorized workers from entering the site.

Highway planting is for aesthetics and for the animals.

Exported topsoil is to remove any excess soil from cutting into the mountains.

Erosion control is for if it rains sediment doesn't runoff into the creek because the excess soil will drain into the ocean.

Chain link fence is a permanent fixture to discourage animals from crossing the highway and funnel them into the culvert.

Based on the assumptions made, this project will cost nearly 4 million dollars. However, this does not cover a variety of things, such as contractors, legal fees, etc, so actual cost is much greater.

A Gant chart, was also created that shows the project duration of the culvert and highway widening. Because the expansion was increased to 10 miles, the project duration is nearly 4 years. This assumption is based on the 805 freeway widening and examples from the construction and scheduling class. The activities do not need to wait for the predecessor to finish and so duration is cut in half. There is about a 2-station lag between laying base and placing asphalt.

The project is broken down into 4 parts; the design, site work, structural, and transportation. Details of each activity, such as duration, predecessor, and successors can be seen in the construction appendix.

Definitions:

Issue contract is when the firm legally has the project and can begin planning and design

Environmental impact statement is a document required by the National Environment Policy Act to describe the positive and negative impacts on the site.

Prepare highway plans are the design of the widening and the culvert.

Reviewing the plans is for another engineer with a fresh eye to see if any mistakes or flaws are made and fixed.

Submitting the plans is sending the plans to the client.

The firm needs to schedule a design public hearing to see what the community has to say of the new additions.

Once all that is complete mobilization of the project can begin. Mobilization is the moving of the equipment needed to start the project.

Then afterwards is excavation, which is the removing of dirt in order to place the culvert.

After excavating, the dirt will be hauled to wherever fill is needed and then hauled out of the site.

Surveying is how elevations, curves and such for the highway will be determined.

Grading is to have the roads at a slope of 2% for runoff is order to keep water of the asphalt.

Drainage is a system for the water to go into pipes that drain to the ocean or to a station.

Buying the precast with enough time to get the structure to the site.

Transport precast is moving the pre-engineered culvert to the site.

Once it is transported, the precast structure is set into its ditch.

Cut and fill can begin once surveying is done, which will cut into the parts of the mountain that are obstructing the way for the widened road and filling in parts that need more land to widen the road.

There is temporary fencing to deter trespassers from entering and then fencing in order to funnel the animals towards the culvert and prevent them from crossing the highway.

Compaction is compacting the dirt for foundation reasons as a base for the highway.

Shrubbery is for aesthetics because all the previous greens will have been uprooted when cutting and filling.

Placing barriers is for the safety of the workers to protect them from oncoming traffic.

End treatment is the barriers for the guardrails themselves, also for safety.

Laying base is for the base of the highway, which is below the asphalt.

Placing asphalt is the body of the road, and will be expanded one lane at a time for traffic flow reasons.

Afterwards, striping is done and finally, guardrails can be placed for safety, so that cars do not go off the road or crash into trees.

Concluding Remarks

Sustainability and Life Cycle Costs

Wildlife Culvert

The overall design of the culvert and highway expansion is highly sustainable. The design and material of the culvert has a long lifespan and only requires occasional maintenance to remove any debris and observe any erosion of the natural channel bottom. Due to the width of the culvert and the minimal amount of water expected to flow through the culvert erosion is not expected to occur.

Unfortunately, life cycle costs are difficult to estimate for culverts. The only data available consist of qualitative statements regarding a range of widely varying types of culverts. A large scale study by the State Department of Transportation would be required to create procedures for describing all costs which include design and maintenance. Additionally, there is no guidance at the national level that can offer comparisons between various culvert designs as far as life cycle costs.

Highway Expansion

Since the expansion is based on an already existing roadway the expansion is also highly sustainable and does not make any major intrusions on the surrounding area. As with any road, the asphalt is likely to wear down and while typical asphalt roads last at least 35 years, rain damage, frost, and excessive braking can cause potholes and other damages. Considering the currently low traffic volume, the highway is expected to last for it's lifetime without the need for any major repairs, barring any unforeseen natural disasters.

Social, Environmental, and Cultural Objections

Social

Social objections to this project are likely to be limited. Complaints could include traffic jams and noise pollution during the construction of the highway expansion. Fortunately, there are means to remediate these problems and once construction is complete the expansion will benefit those of the nearby communities by alleviating traffic.

Others in the community might also complain about the expenditure of tax dollars on a project that they might see no merit in completing. Community meetings will be a crucial part of the project and will be required in order to address the various concerns that the community is likely to have.

It is highly unlikely that there will be any objections to the highway culvert. Since the staging area for construction is away from the highway and the culvert will be installed using trenchless technology, the community will not be affected by the construction of the culvert.

Environmental

This project will ultimately have a positive environmental effect. Since the culvert will guide wildlife underneath the highway instead of across it there will be a significant reduction in the number of animal fatalities and the associated number vehicular damages. The highway expansion was designed with environmental concerns in mind and while it may make crossing for animals more difficult in areas, the fencing that will guide local fauna to the culvert should remediate this problem and eliminate any concern.

Cultural

The area which the highway expansion will cross through is on Native American land owned by the Kumeyaay Tribe. This could cause concerns should the highway expansion cross through any sacred sites. This is a concern that will need to be addressed long before construction begins and at the beginning of the design process. Ultimately, the expansion will benefit the Kumeyaay by allowing more traffic to travel to the proposed Kumeyaay Casino. For this reason it is likely that the Kumeyaay will be highly cooperative with construction and planning efforts.

Final Remarks

This project will ultimately be beneficial to the community and to the environment. The highway expansion, although inconvenienceing during construction, will ultimately alleviate heavy traffic by doubling the number of lanes. The addition of the wildlife culvert will also have a significant and positive environmental impact by giving animals an opportunity to cross to the other side of the highway without the concern of becoming roadkill. The community will also benefit from safer driving conditions and reduced traffic accidents resulting from animals on the road.

The lifetime and maintenance costs of this project are also expected to be very manageable. Since asphalt highways in low traffic conditions often exceed their expected 35 year lifespan minimal maintenance will be required and major repairs are only likely should a natural disaster, such as an earthquake, occur.

Maintenance and construction of the culvert is also expected to be within a fairly reasonable range. Since the final design will be precast construction will be swift and maintenance will be minimal, consisting of debris removal and soil leveling in the event of a large flood.

Implementation of the designs for this project will result in significant positive impacts on the community and the environment and should be given serious consideration in order to create a more sustainable future for people and wildlife.

From everyone at team SIMBA, we would like to thank our instructors and advisors:
Ron Rempel – San Diego Management and Monitoring Program, SR-94 Connectivity Coordinator
Kris Preston – San Diego Management and Monitoring Program, Biologist
Carlton Rochester – US Geological Survey, Connectivity Evaluations
John Martin – US Fish and Wildlife Service, San Diego
Zaid Bayasi – San Diego State University, Structural Professor
Sam Amen – San Diego State University, Highway Transportation Professor

Without your help and guidance, this project would not be where is it. At this point in the project, team SIMBA is finalizing minor details in the planning phase. When further information can be obtained, missing areas can be filled in. In the remaining weeks of this project, we will be working on the design phase, using computer aided design programs to achieve a detailed visual representation of the wildlife culvert and highway expansion. Although this is a school-based project, we hope our project can inspire capable others to actually implement a wildlife culvert along SR-94 to save wildlife and increase habitat connectivity.

Best regards,

Brian Tran
Project Manager
San Diego State University

Appendix A – References

http://www.azgfd.gov/hgis/pdfs/CulvertGuidelinesforWildlifeCrossings.pdf

http://www.cflhd.gov/programs/techdevelopment/wildlife/documents/03_Chapter_1_Introduction.pdf

Figure 1.1 http://www.wildlifeandroads.org/decisionguide/2_1_6.cfm

Figure 2.1 http://www.cflhd.gov/programs/techdevelopment/wildlife/documents/01_Wildlife_Crossing_Structures_Handbook.pdf

Figure 2.2 http://www.cflhd.gov/programs/techdevelopment/wildlife/documents/01_Wildlife_Crossing_Structures_Handbook.pdf

Figure 2.3 http://www.cflhd.gov/programs/techdevelopment/wildlife/documents/01_Wildlife_Crossing_Structures_Handbook.pdf

Figure 3.1 http://www.azgfd.gov/hgis/pdfs/CulvertGuidelinesforWildlifeCrossings.pdf

Figure 3.2 http://www.azgfd.gov/hgis/pdfs/CulvertGuidelinesforWildlifeCrossings.pdf

http://www.usgs.gov/pubprod/

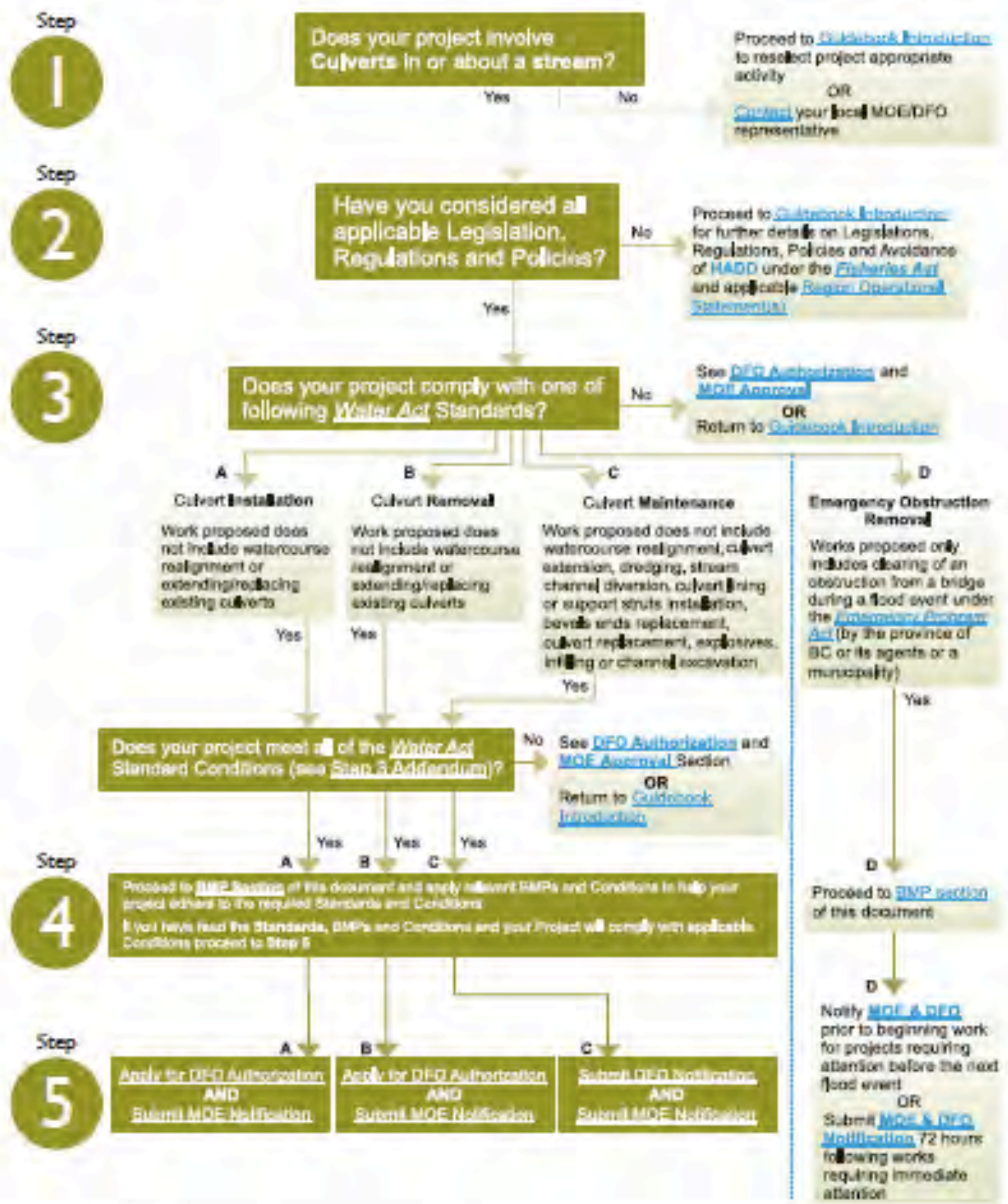
http://www.sandag.org/index.asp?classid=26&fuseaction=home.classhome

http://pereview.net/wp-content/uploads/pdf/hcm-extracts.pdf

http://sv08data.dot.ca.gov/contractcost/index.php

Appendix B – Environmental

The following **five (5) steps** will help guide you through the provincial and federal Notification, Approval and/or Authorization process for **Culvert Installation, Maintenance** or **Removal** works:



Culverts – Standards and Best Practices for Instream Works 3

Appendix C – Structural

See Attached papers

Appendix D – Hydrology

Calculations

INLET CONTROL:

$AD^{0.5} = (40)(1.3)^{0.5} = 14.28$

$Q/AD^{0.5} = 36/14.28 = 2.52$

HW/D = 0.90, therefore:

$HW = HW_t (0.90)(20) = 18$ ft

EL_{hi} 620+18= 638.0 ft

For the check flow:

$Q/AD^{0.5} = 3.44$

HW/D = 1.13, therefore:

$HW = HW_t (1.13)(20)$ 22.6 ft

$EL_{hi} =$ 620+ 22.6= 642.6 ft

OUTLET CONTROL:

Backwater calculations will be necessary to check Outlet Control.

Backwater Calculations

From hydraulic tables for concrete box:

for Q = 30 ft^3/s, dc = 12.4 ft

for Q = 36ft^3/s, dc = 14.6 ft

Since TW > dc, start backwater calculations at TW depth.

Determine normal depths (dn) using hydraulic tables.

for Q = 30 ft^3/s, n = 0.034 ;

dn = 13.1 ft

for Q = 36 ft^3/s, n = 0.034 ;

dn = 16.7 ft

since dn > dc, flow is subcritical

since TW > dn, water surface has an M-1 profile

Plot Area and Hydraulic Radius vs. depth from data obtained from tables.

d/D	d	A/BD	A	R/D	R
0.65	13.0	0.5537	332.2	0.3642	7.28
0.70	14.0	0.6013	360.8	0.3781	7.56
0.75	15.0	0.6472	388.3	0.3886	7.77
0.80	16.0	0.6908	414.5	0.3950	7.90
0.85	17.0	0.7313	438.8	0.3959	7.92
0.90	18.0	0.7671	460.3	0.3870	7.74
0.95	19.0	0.7953	477.2	0.3649	7.30
1.00	20.0	0.8108	486.5	0.3060	6.12

Complete Water Surface Computations

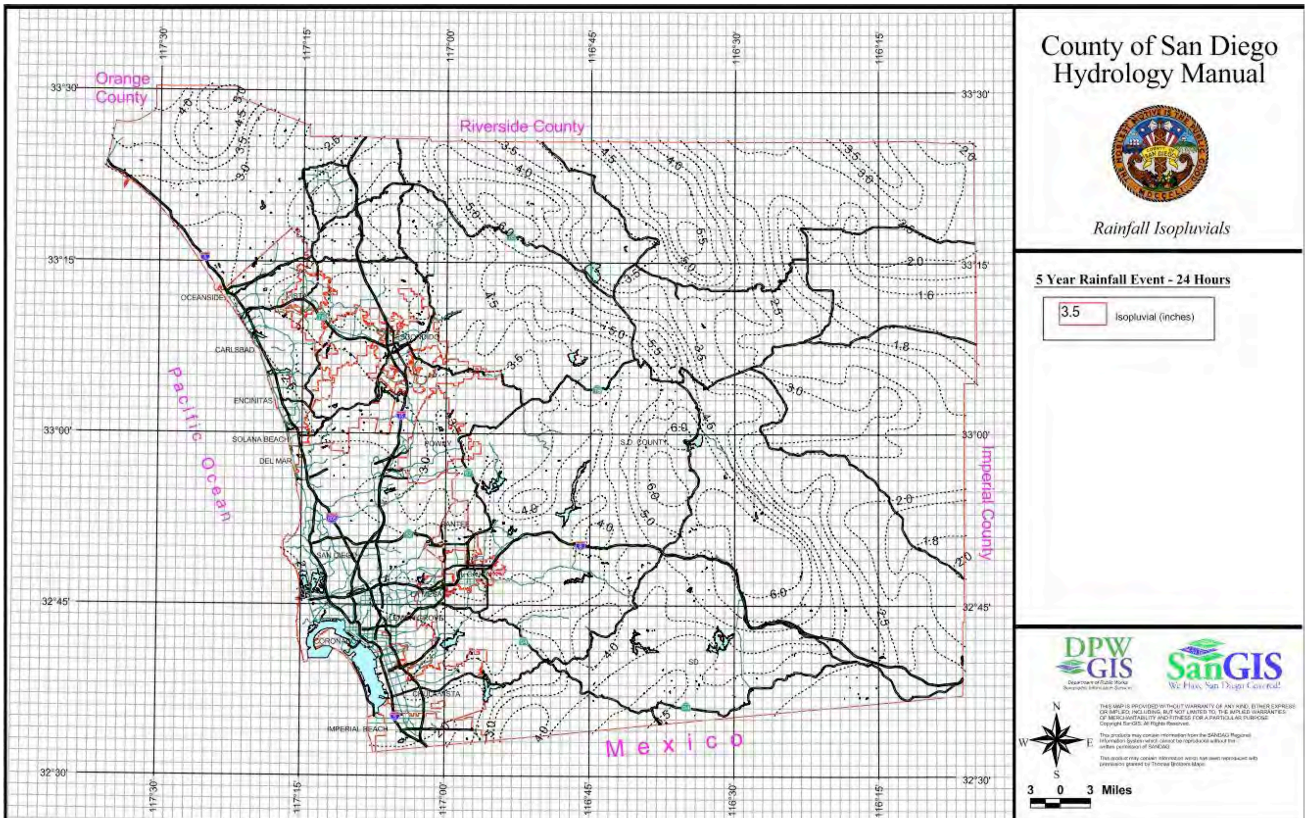
HW = specific head (H) + $k_e (V^2/2g)$

Neglecting approach velocity head :

for Q = 30 ft³/s:
HW = 18.004 + (0.5)(3.208) = 19.6 ft
EL_{ho} = 620 + 19.6 = 639.6 ft

for Q = 36 ft³/s:
HW_f = 22.627 + (0.5)(3.89) = 24.6 ft
EL_{ho} = 620 + 24.6 = 644.6 ft
SUMMARY:
DESIGN Q:

EL_{hd}	EL_{hi}	EL_{ho}
640.0	638.0	639.6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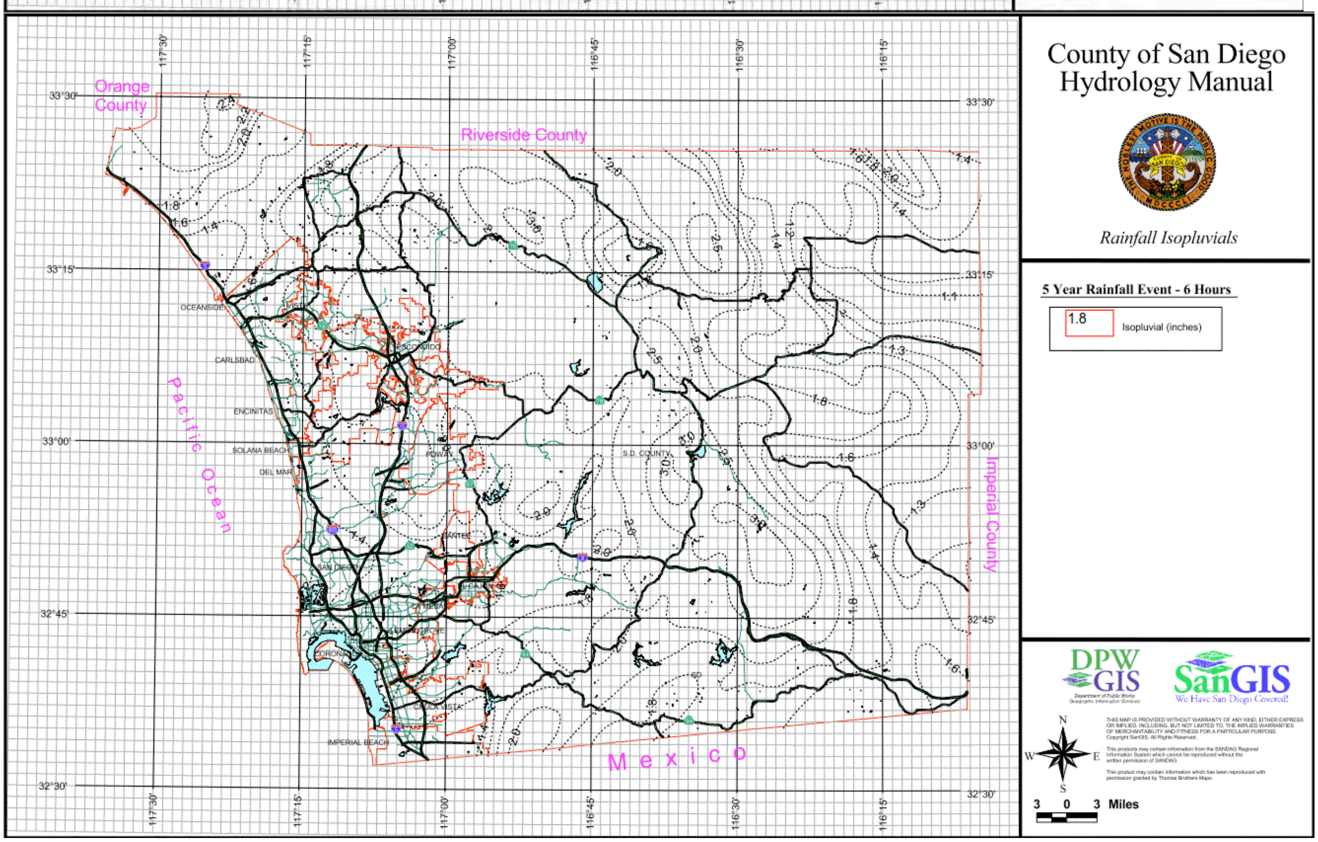
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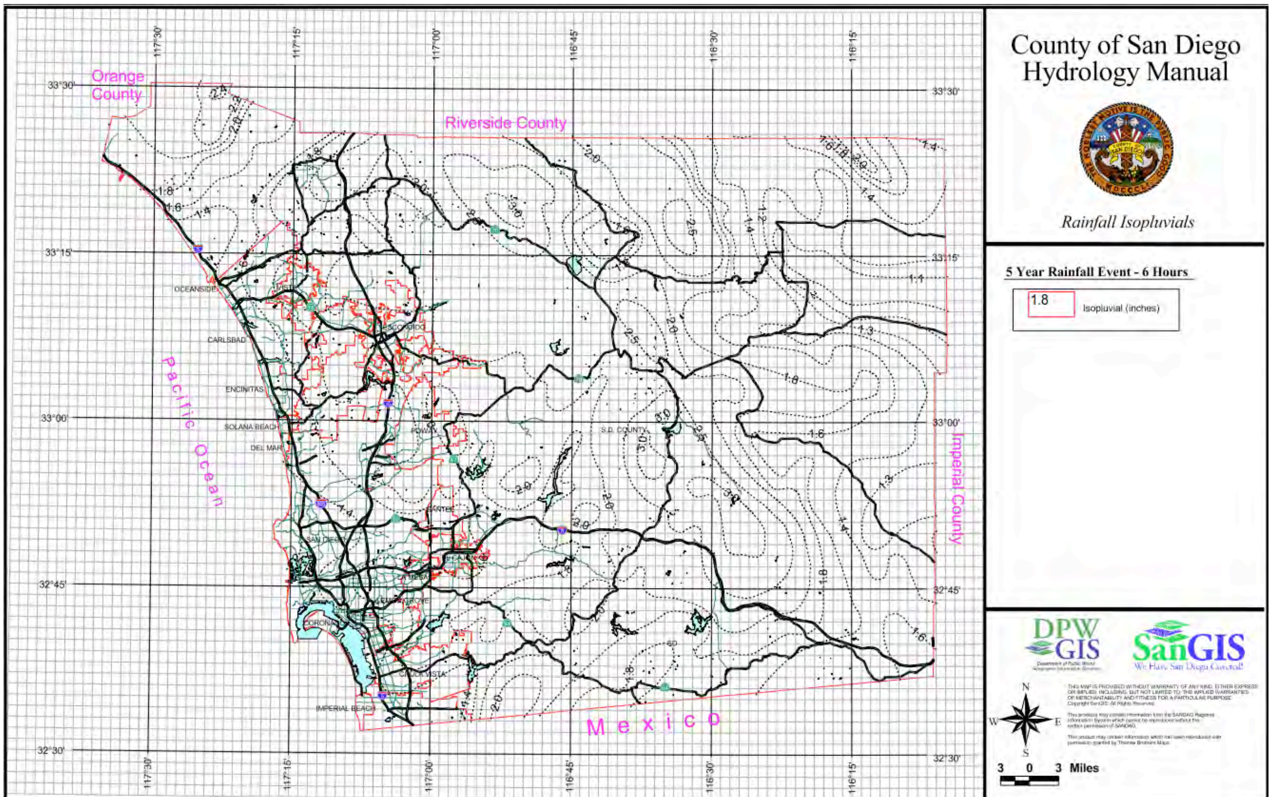
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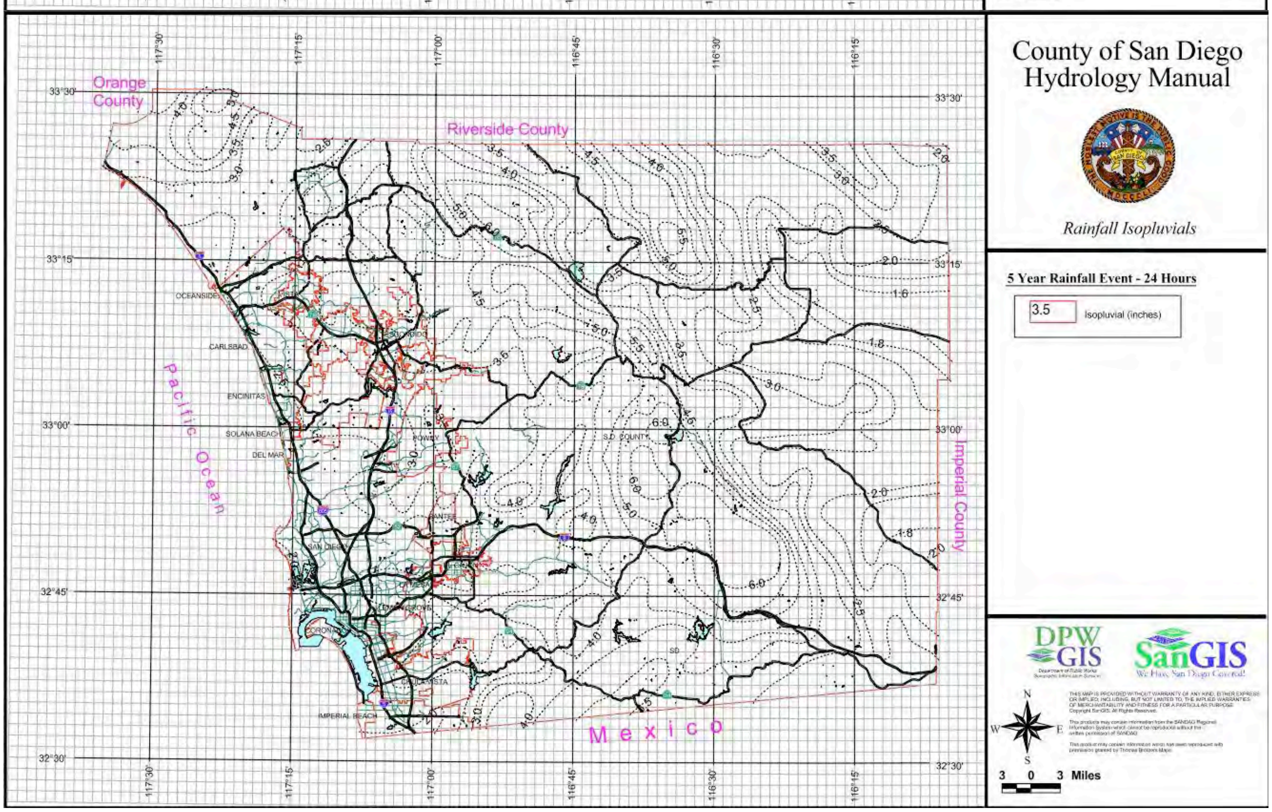
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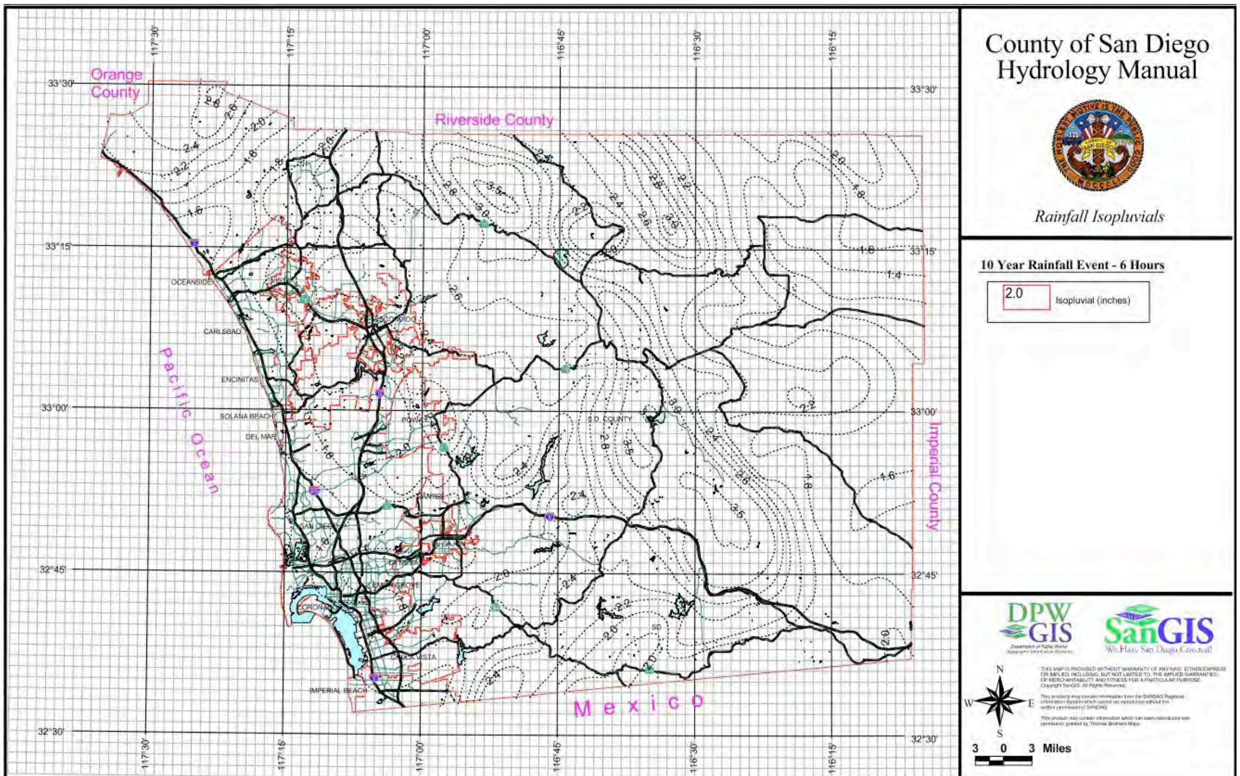
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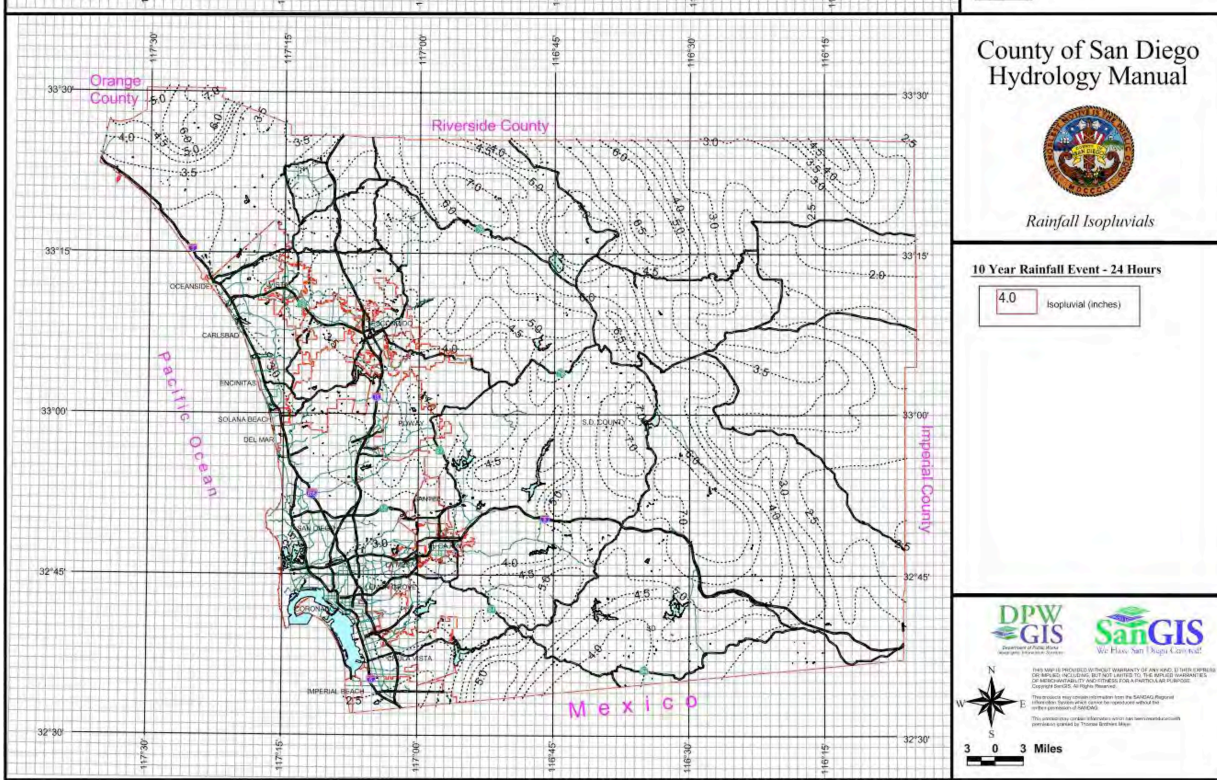
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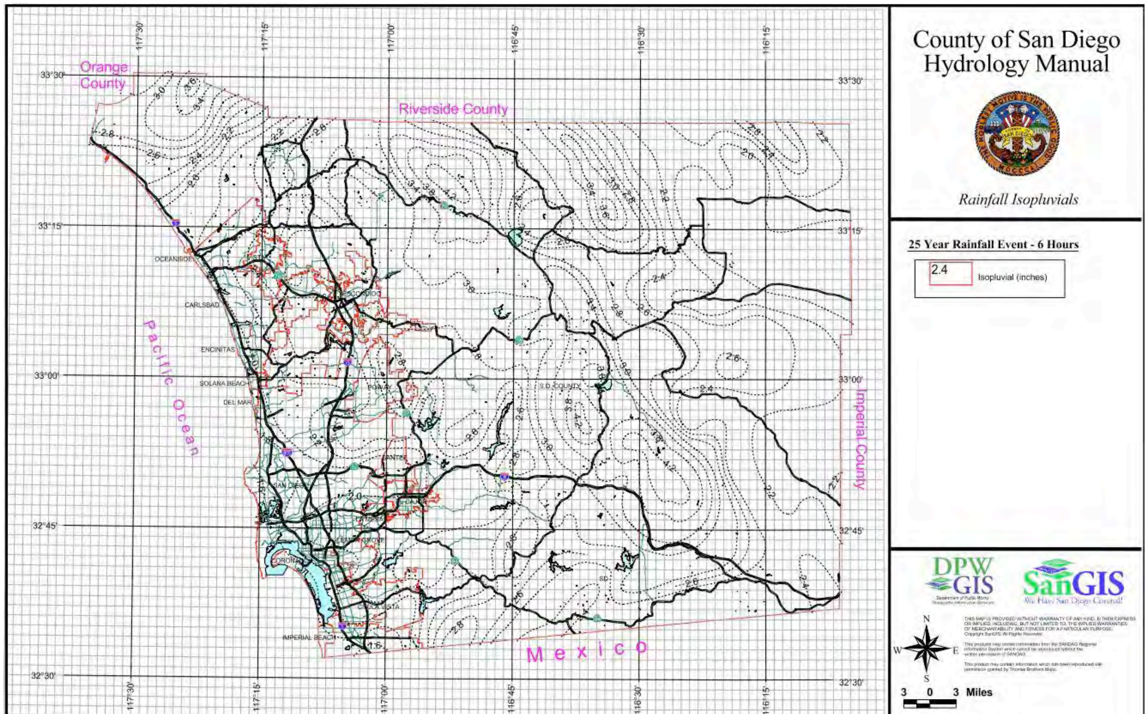
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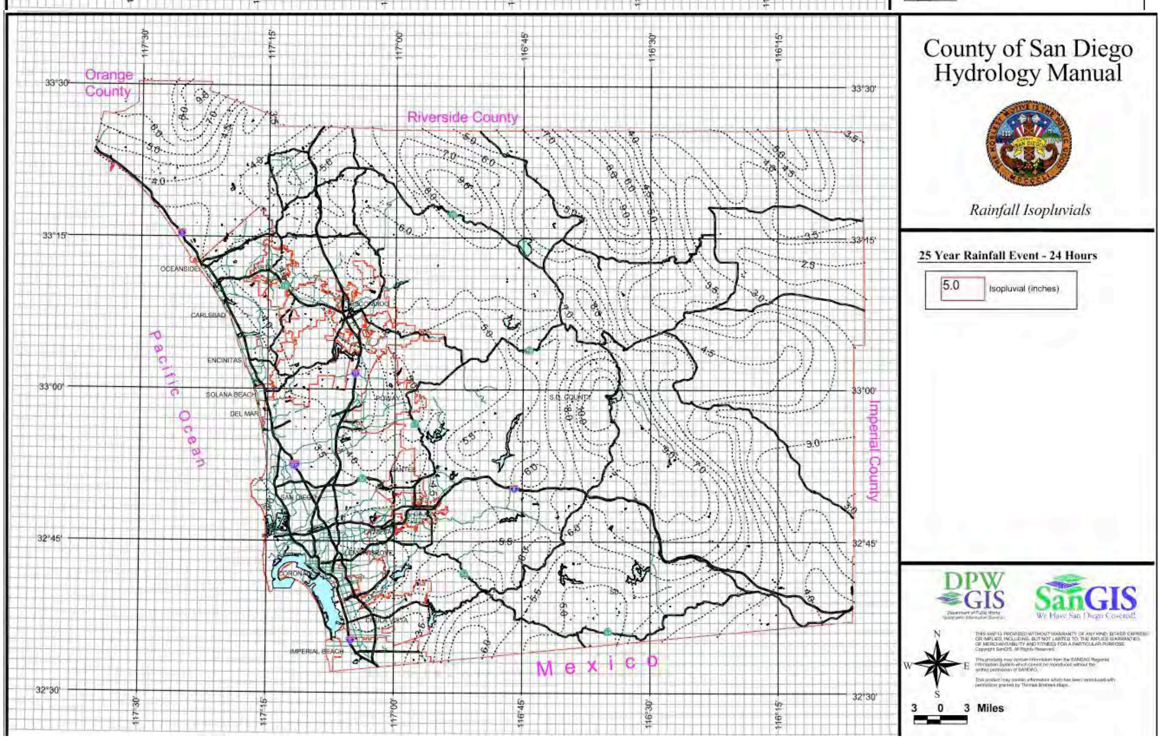
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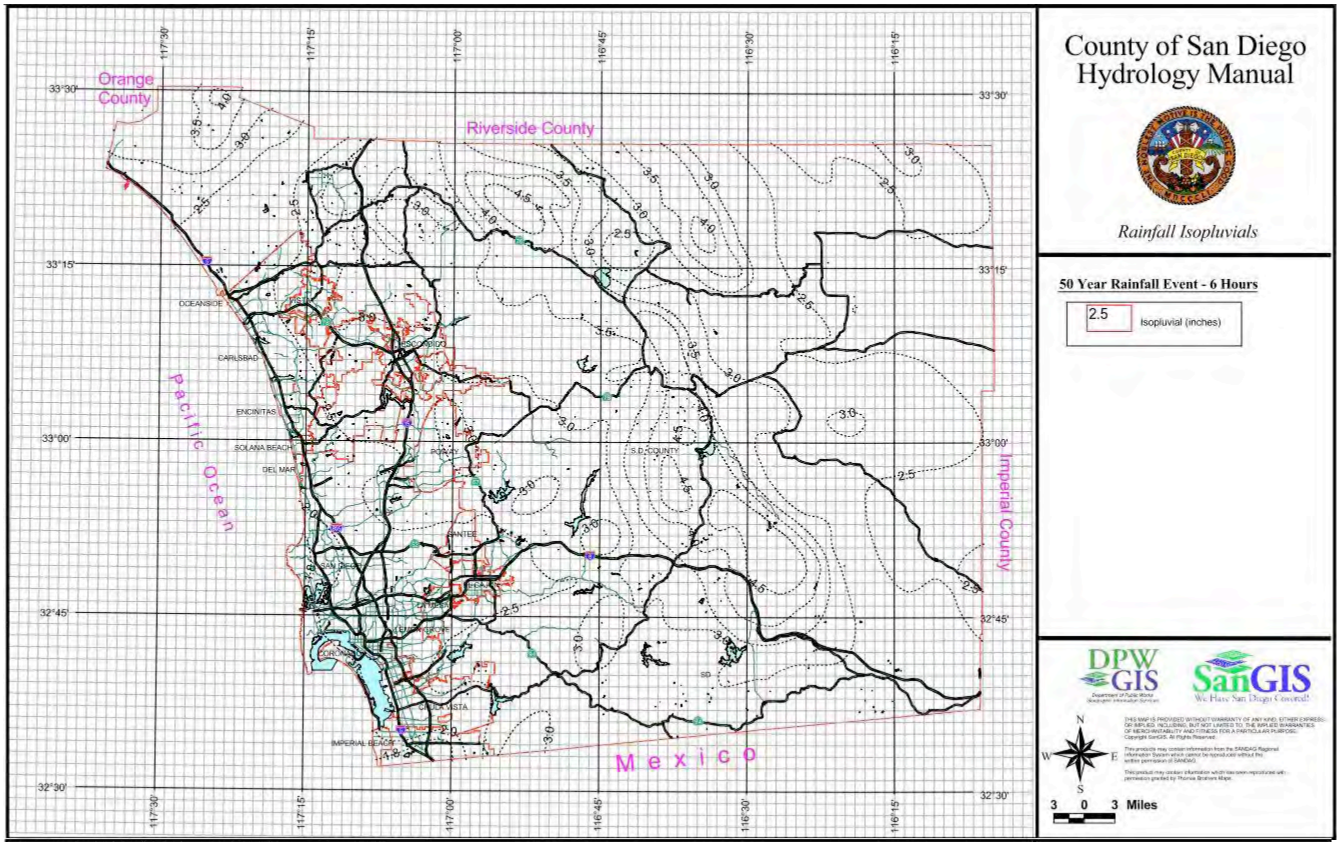
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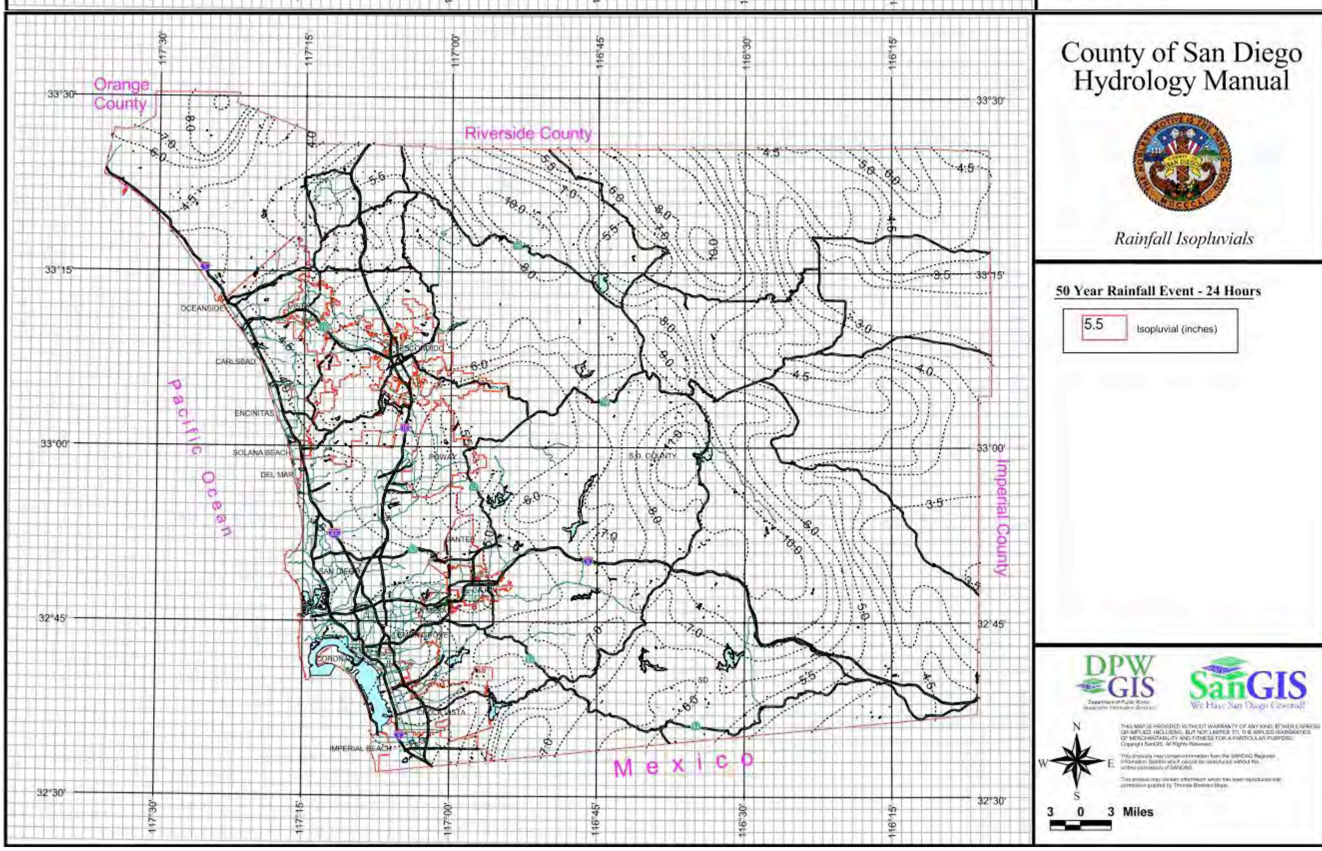
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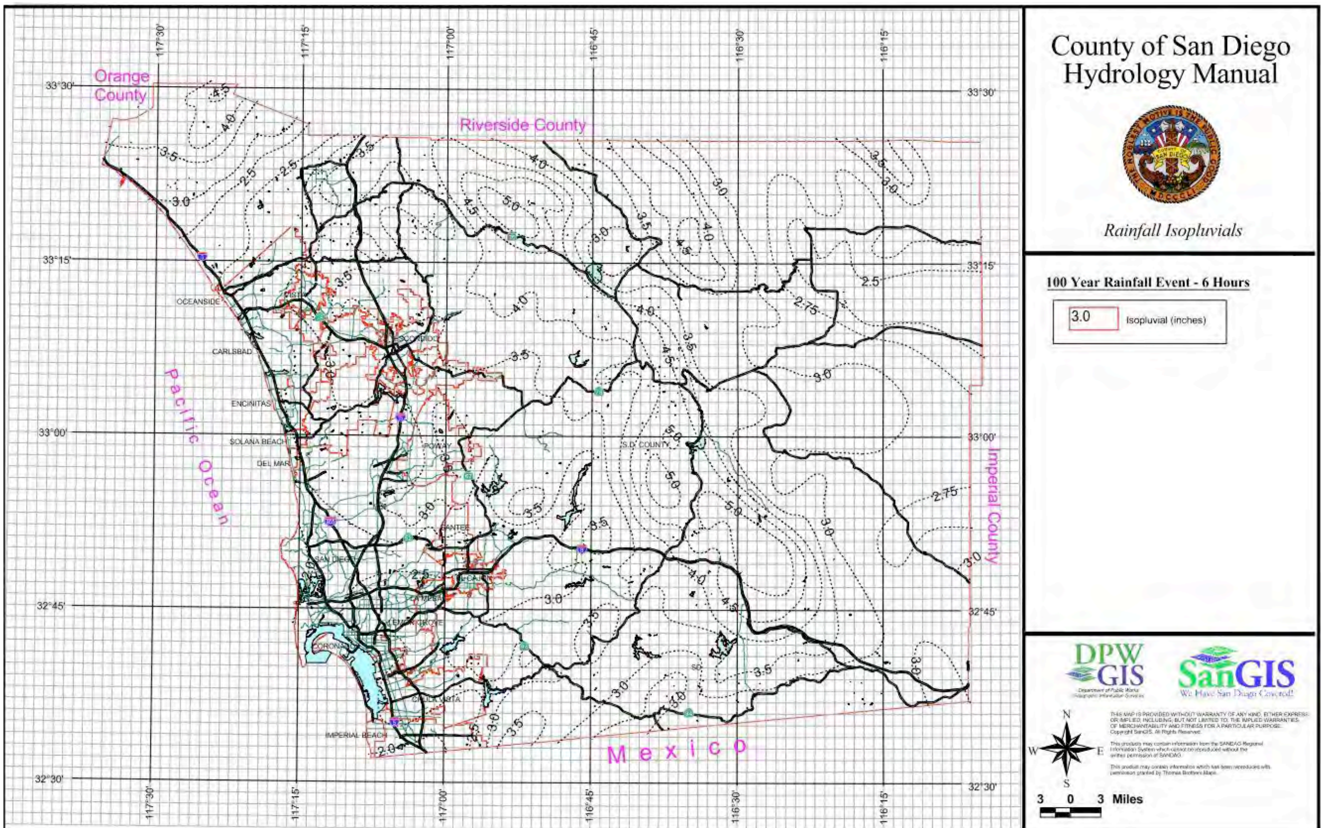
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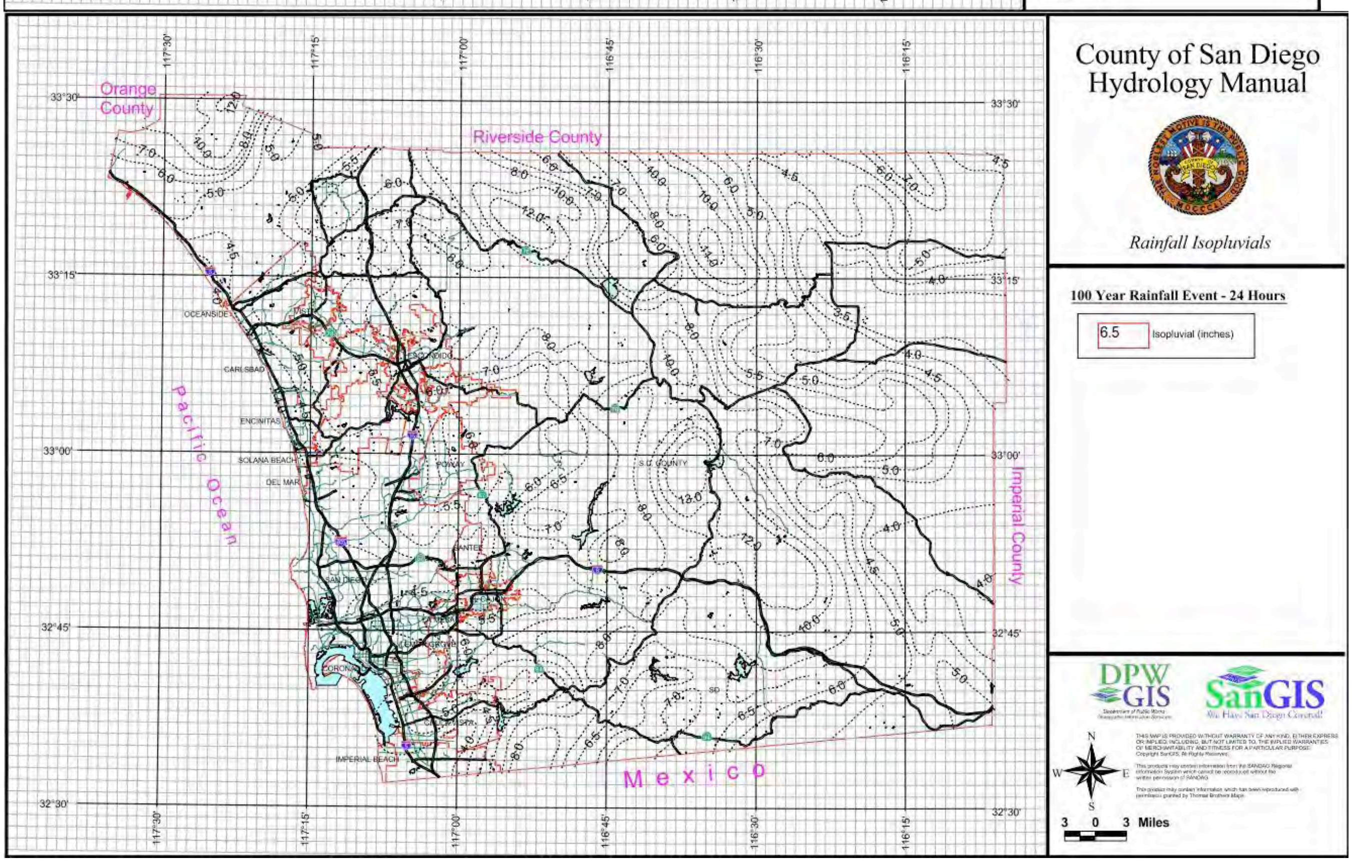
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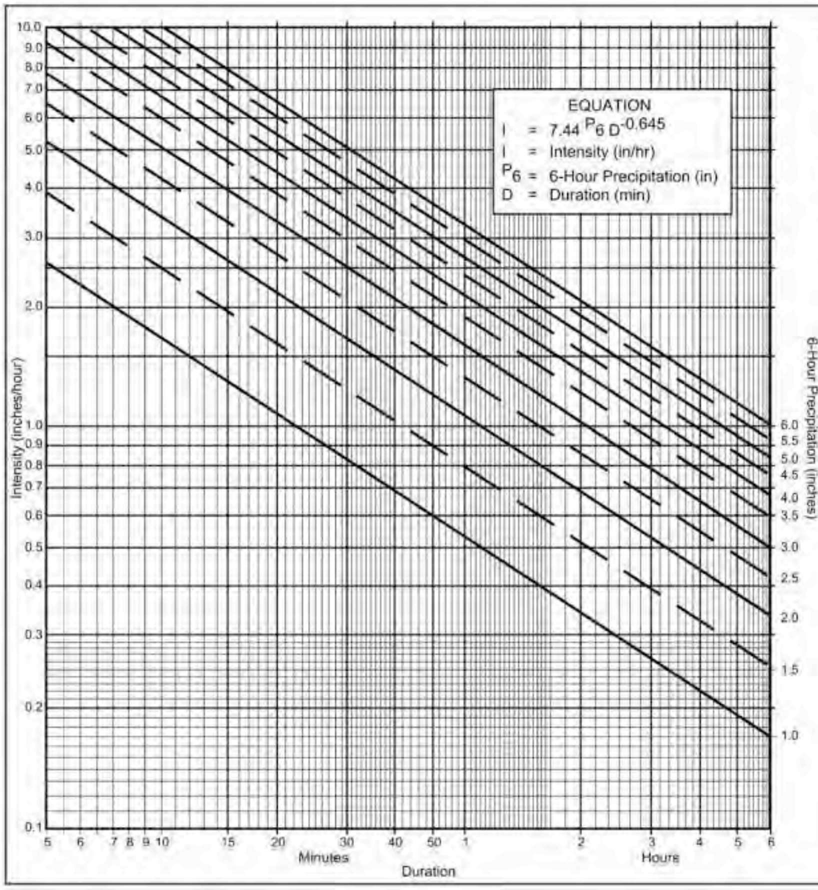


Directions for Application:

(1) From precipitation maps determine 6 hr and 24 hr amounts for the selected frequency. These maps are included in the County Hydrology Manual (10, 50, and 100 yr maps included in the Design and Procedure Manual).

(2) Adjust 6 hr precipitation (if necessary) so that it is within the range of 45% to 65% of the 24 hr precipitation (not applicaple to Desert).

(3) Plot 6 hr precipitation on the right side of the chart.

(4) Draw a line through the point parallel to the plotted lines.

(5) This line is the intensity-duration curve for the location being analyzed.

Application Form:

(a) Selected frequency 100 year

(b) P_6 = 3.0 in., P_{24} = 6.5, $\frac{P_6}{P_{24}}$ = 46 %(2)

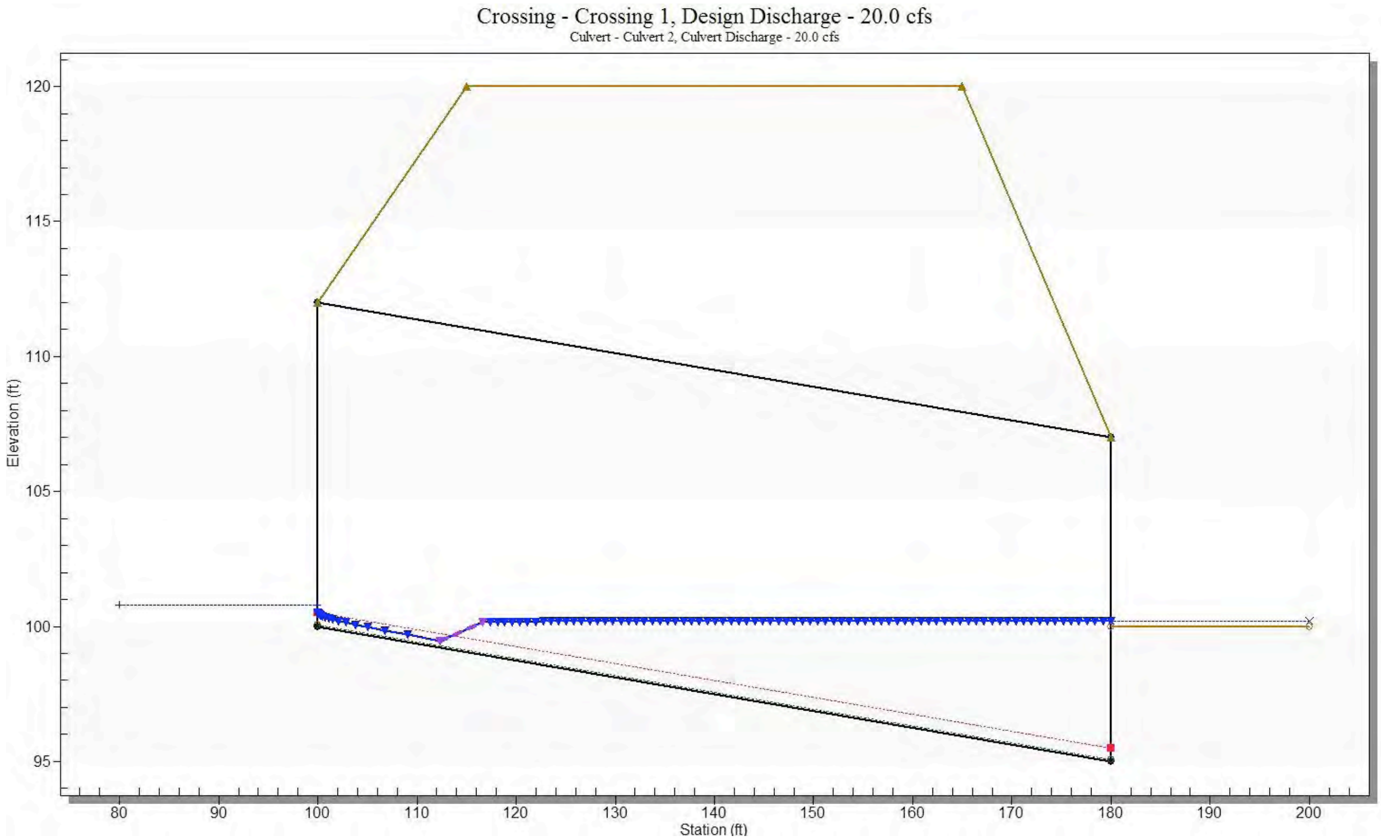
(c) Adjusted $P_6^{(2)}$ = 3.5 in.

(d) t_x = 30 min.

(e) I = 3.0 in./hr.

Note: This chart replaces the Intensity-Duration-Frequency curves used since 1965.

P6	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6
Duration	I	I	I	I	I	I	I	I	I	I	I
5	2.63	3.95	5.27	6.59	7.90	9.22	10.54	11.86	13.17	14.49	15.81
7	2.12	3.18	4.24	5.30	6.36	7.42	8.48	9.54	10.60	11.66	12.72
10	1.68	2.53	3.37	4.21	5.05	5.90	6.74	7.58	8.42	9.27	10.11
15	1.30	1.95	2.59	3.24	3.89	4.54	5.19	5.84	6.49	7.13	7.78
20	1.08	1.62	2.15	2.69	3.23	3.77	4.31	4.85	5.39	5.93	6.46
25	0.93	1.40	1.87	2.33	2.80	3.27	3.73	4.20	4.67	5.13	5.60
30	0.83	1.24	1.66	2.07	2.49	2.90	3.32	3.73	4.15	4.56	4.98
40	0.69	1.03	1.38	1.72	2.07	2.41	2.76	3.10	3.45	3.79	4.13
50	0.60	0.90	1.19	1.49	1.79	2.09	2.39	2.69	2.98	3.28	3.58
60	0.53	0.80	1.06	1.33	1.59	1.86	2.12	2.39	2.65	2.92	3.18
90	0.41	0.61	0.82	1.02	1.22	1.43	1.63	1.84	2.04	2.25	2.45
120	0.34	0.51	0.68	0.85	1.02	1.19	1.36	1.53	1.70	1.87	2.04
150	0.29	0.44	0.59	0.73	0.88	1.03	1.18	1.32	1.47	1.62	1.76
180	0.26	0.39	0.52	0.65	0.78	0.91	1.04	1.18	1.31	1.44	1.57
240	0.22	0.33	0.43	0.54	0.65	0.76	0.87	0.98	1.08	1.19	1.30
300	0.19	0.28	0.38	0.47	0.56	0.66	0.75	0.85	0.94	1.03	1.13
360	0.17	0.25	0.33	0.42	0.50	0.58	0.67	0.75	0.84	0.92	1.00



HY-8 Analysis Results

Culvert Summary Table - Culvert 2

Culvert Crossing: Crossing 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	100.00	0.00	0.0	0-NF	0.00	0.00	5.00	0.00	0.00	0.00
2.70	2.68	100.21	0.21	0.06	1-JS1t	0.01	0.13	5.06	0.06	0.05	1.13
5.40	5.38	100.34	0.34	0.09	1-JS1t	0.02	0.21	5.09	0.09	0.11	1.49
8.10	8.07	100.44	0.44	0.12	1-JS1t	0.03	0.27	5.12	0.12	0.16	1.75
10.80	10.78	100.53	0.53	0.14	1-JS1t	0.04	0.33	5.14	0.14	0.21	1.97
13.50	13.49	100.62	0.62	0.16	1-JS1t	0.05	0.38	5.16	0.16	0.26	2.15
16.20	16.16	100.70	0.70	0.18	1-JS1t	0.06	0.43	5.18	0.18	0.31	2.31
18.90	18.87	100.77	0.77	0.19	1-JS1t	0.07	0.48	5.19	0.19	0.36	2.46
20.00	19.99	100.80	0.80	0.20	1-JS1t	0.07	0.50	5.20	0.20	0.38	2.52
24.30	24.27	100.92	0.92	0.22	1-JS1t	0.08	0.57	5.22	0.22	0.46	2.72
27.00	26.98	100.98	0.98	0.24	1-JS1t	0.09	0.61	5.24	0.24	0.52	2.83

HY-8 Energy Dissipation Report

Scour Hole Geometry

Parameter	Value	Units
Select Culvert and Flow		
Crossing	Crossing 1	
Culvert	Culvert 2	
Flow	27.00	cfs
Culvert Data		
Culvert Width (including multiple barrels)	10.0	ft
Culvert Height	12.0	ft
Outlet Depth	5.24	ft
Outlet Velocity	0.52	ft/s
Froude Number	0.04	
Tailwater Depth	0.24	ft
Tailwater Velocity	2.83	ft/s
Tailwater Slope (SO)	0.0625	
Scour Data		
Time to Peak		
Note:	if Time to Peak is unknown, enter 3 min	
Time to Peak	30.00	min
Cohesion	Noncohesive	
D16 Value	0.00	mm
D84 Value	0.00	mm
Tailwater Flow Depth after Culvert Outlet	Normal Depth	
Enter all required input before computation will occur		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US Topo
JAMUL MOUNTAINS QUADRANGLE
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SCALE 1:24 000
ROAD CLASSIFICATION
JAMUL MOUNTAINS, CA
2012

Appendix E – Transportation

Current Traffic Data:

Description	Back Peak hour	Back Peak Month	Back AADT	Ahead Peak Hour	Ahead Peak AADT	Ahead AADT
JCT. RTE. 54 NORTH	5300	63000	61000	1450	17000	16700
STEEL CANYON ROAD	1300	15500	15700	1350	16600	16100
LYONS VALLEY ROAD	1350	16600	16100	920	10900	10800
HONEY SPRINGS ROAD	690	7700	7500	570	6400	6300

ADT - Average Daily Traffic

DHV - Design Hour Volume, percentage of traffic that flows during peak hour volume

-(Assumed)

$$DHV = ADT * \%DHV * D$$

D - Peak hour Direction Split (Assumed)

V - Speed (mph)

Lane Capacity - Vehicles per lane (vpl)

N - Number of lanes

Current Lane Size:

Steele Canyon Road - Lyons Valley Road:

$$ADT(2012) = 16600$$
$$DHV = 11\%*ADT$$
$$D = 60\%$$
$$V = 55 \ mph$$
$$Lane \ Capacity = 2200 \ vpl$$

$$DHV = 16600*0.11*0.6 = 1095.6$$
$$LOS(C) = 0.64$$
$$Capacity = 0.64*2200 = 1408$$

LOS (C) obtained from HCM Exhibit 23-2

$$N = \frac{1095.6}{1408} = 0.78$$

N = 1 lane in each direction , or 2 lanes total.

Lyons Valley Road - Honey Springs Road:

$$ADT(2012) = 10900$$
$$DHV = 11\%*ADT$$
$$D = 60\%$$
$$V = 55 \ mph$$
$$Lane \ Capacity = 2200 \ vpl$$

$$DHV = 10900*0.11*0.6 = 719.4$$
$$LOS(C) = 0.64$$
$$Capacity = 0.64*2200 = 1408$$
$$N = \frac{719.4}{1408} = 0.51$$

N = 1 lane in each direction, or 2 lanes total.

References.

"Chapter 200 Geometric Design and Structure Standards." California Department of Transportation, 7 May 2012. Web. 1 Dec. 2013. <http://www.dot.ca.gov/hq/oppd/hdm/pdf/english/chp0200.pdf>.

General Info. U.S. Department of the Interior Bureau of Land Management, n.d. Web. 1 Dec. 2013. <http://www.blm.gov/wo/st/en/prog/energy/cost_recovery_regulations/general_info.html>.

"Level-of-Service Criteria for Basic Freeway Segments." Transportation Research Board of the National Academies, 2010. Web. 1 Dec. 2013.

<http://pereview.net/wp-content/uploads/pdf/hcm-extracts.pdf>.

"Manual on Uniform Traffic Control Devices (MUTCD)." *California MUTCD 2012*. California Department of Transportation, 2012. Web. 3 Dec. 2013. <http://www.dot.ca.gov/hq/traffops/signtech/mutcdsupp/ca_mutcd2012.htm>.

Table 203.2
Standards for Curve Radius

Design Speed mph	Minimum Radius of Curve (ft)
20	130
30	300
40	550
50	850
60	1,150
70	2,100
80	3,900

Table 202.2

Standard Superelevation Rates
(Superelevation in Feet per Foot for Curve Radius in Feet)

Ramps, 2-Lane Conventional Highways, Frontage Roads[1]		Freeways, Expressways, Multilane Conventional Highways		When Snow & Ice Conditions Prevail (Usually over 3,000 ft elevation)		Urban Roads (35 – 45 mph)		Urban Roads (less than 35 mph)	
For e_{max} = 0.12		For e_{max} = 0.10		For e_{max} = 0.08		For e_{max} = 0.06		For e_{max} = 0.04	
Range of Curve Radii	e Rate	Range of Curve Radii	e Rate	Range of Curve Radii	e Rate	Range of Curve Radii	e Rate	Range of Curve Radii	e Rate
Under 625	0.12								
625 – 849	0.11								
850 – 1,099	0.10	Under 1,100	0.10						
1,100 – 1,349	0.09	1,100 – 1,349	0.09						
1,350 – 1,599	0.08	1,350 – 1,599	0.08	Under 1,600	0.08				
1,600 – 1,899	0.07	1,600 – 1,899	0.07	1,600 – 1,899	0.07				
1,900 – 2,199	0.06	1,900 – 2,199	0.06	1,900 – 2,199	0.06	Under 600	0.06		
2,200 – 2,699	0.05	2,200 – 2,699	0.05	2,200 – 2,699	0.05	600 – 999	0.05		
2,700 – 3,499	0.04	2,700 – 3,499	0.04	2,700 – 3,499	0.04	1,000 – 1,499	0.04	Under 500	0.04
3,500 – 4,499	0.03	3,500 – 4,499	0.03	3,500 – 4,499	0.03	1,500 – 1,999	0.03	500 – 999	0.03
4,500 – 19,999	0.02	4,500 – 19,999	0.02	4,500 – 19,999	0.02	2,000 – 6,999	0.02	1,000 – 4,999	0.02
20,000 & over	(2)	20,000 & over	(2)	20,000 & over	(2)	7,000 & over	(2)	5,000 & over	(2)

NOTES:

(1) For frontage roads under other jurisdictions see Index 202.7.

(2) Use standard crown section.

TABLE 5

Operational Effects of Lane and Shoulder Width on Two-Lane Highways

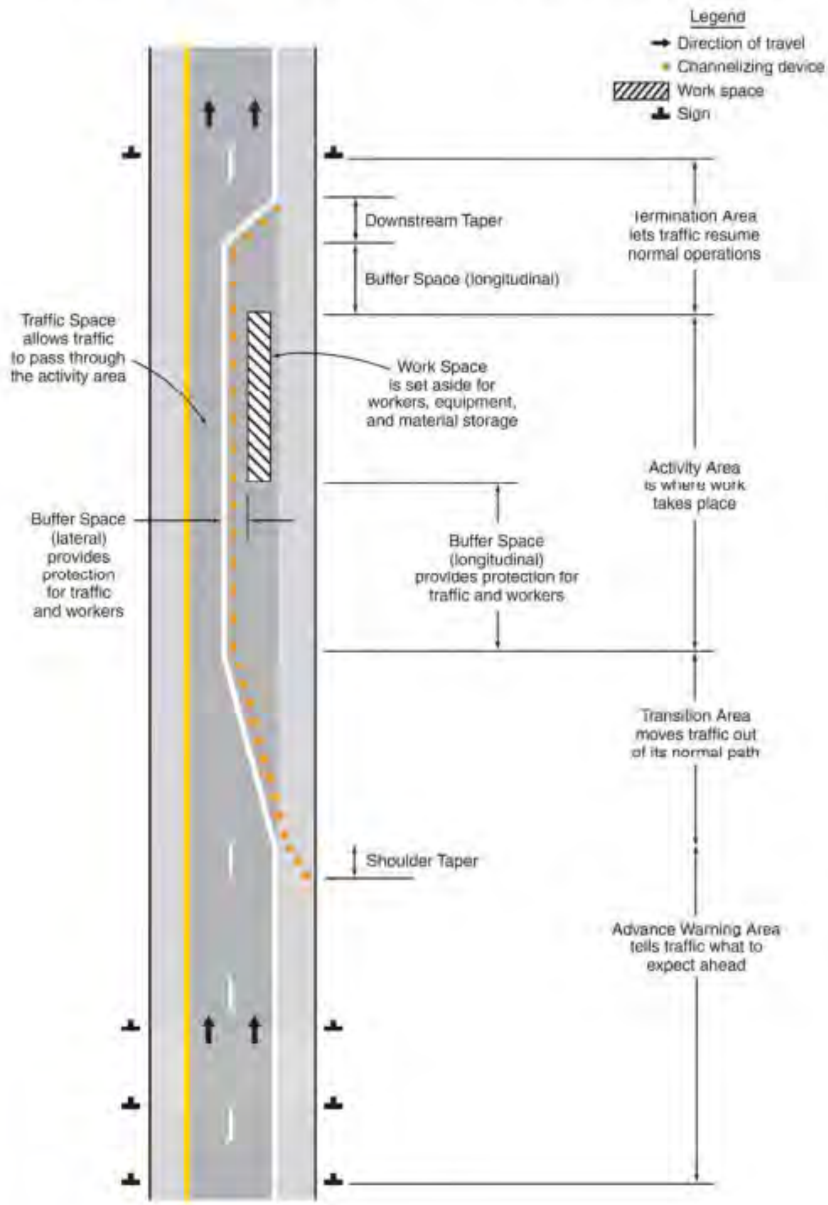
Lane width (ft)	**Reduction in Free-Flow Speed (mi/h)**			
	Shoulder Width (ft)			
	≥0<2	≥2<4	≥4<6	≥6
9<10	6.4	4.8	3.5	2.2
≥10<11	5.3	3.7	2.4	1.1
≥11<12	4.7	3.0	1.7	0.4
≥3.6	4.2	2.6	1.3	0.0

EXHIBIT 23-2. LOS CRITERIA FOR BASIC FREEWAY SEGMENTS

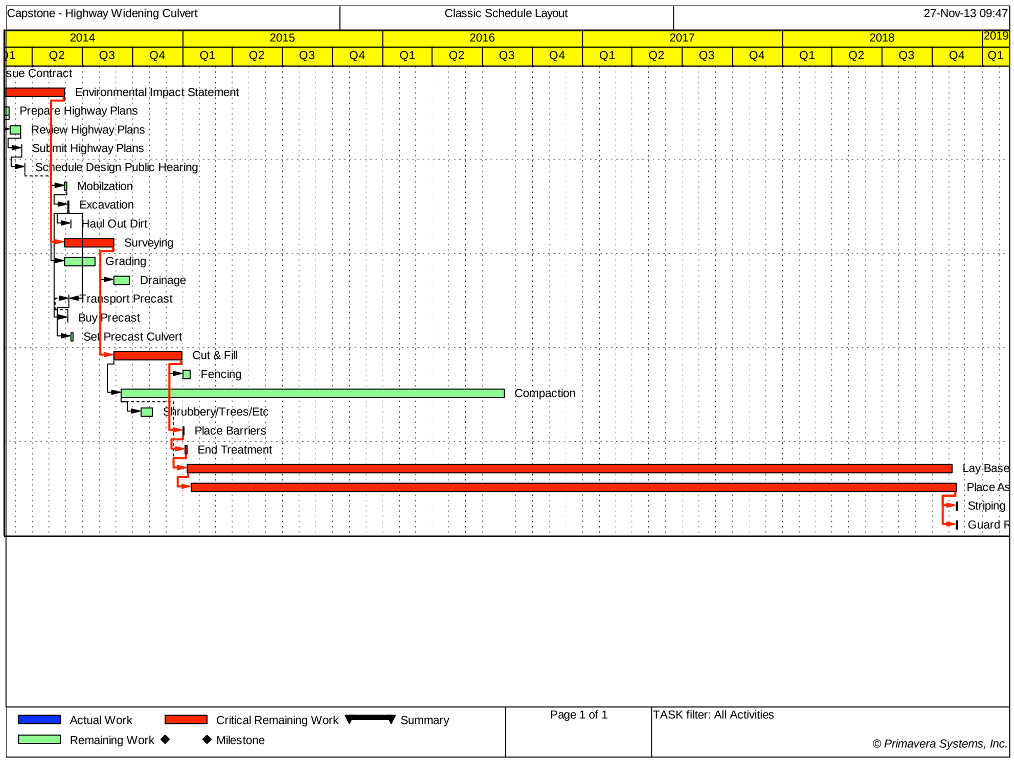
Criteria	LOS				
	A	B	C	D	E
FFS = 75 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	45
Minimum speed (mi/h)	75.0	74.8	70.6	62.2	53.3
Maximum v/c	0.34	0.56	0.76	0.90	1.00
Maximum service flow rate (pc/h/ln)	820	1350	1830	2170	2400
FFS = 70 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	45
Minimum speed (mi/h)	70.0	70.0	68.2	61.5	53.3
Maximum v/c	0.32	0.53	0.74	0.90	1.00
Maximum service flow rate (pc/h/ln)	770	1260	1770	2150	2400
FFS = 65 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	45
Minimum speed (mi/h)	65.0	65.0	64.6	59.7	52.2
Maximum v/c	0.30	0.50	0.71	0.89	1.00
Maximum service flow rate (pc/h/ln)	710	1170	1680	2090	2350
FFS = 60 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	45
Minimum speed (mi/h)	60.0	60.0	60.0	57.6	51.1
Maximum v/c	0.29	0.47	0.68	0.88	1.00
Maximum service flow rate (pc/h/ln)	660	1080	1560	2020	2300
FFS = 55 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	45
Minimum speed (mi/h)	55.0	55.0	55.0	54.7	50.0
Maximum v/c	0.27	0.44	0.64	0.85	1.00
Maximum service flow rate (pc/h/ln)	600	990	1430	1910	2250

Note:
The exact mathematical relationship between density and v/c has not always been maintained at LOS boundaries because of the use of rounded values. Density is the primary determinant of LOS. The speed criterion is the speed at maximum density for a given LOS.

Figure 6C-1. Component Parts of a Temporary Traffic Control Zone

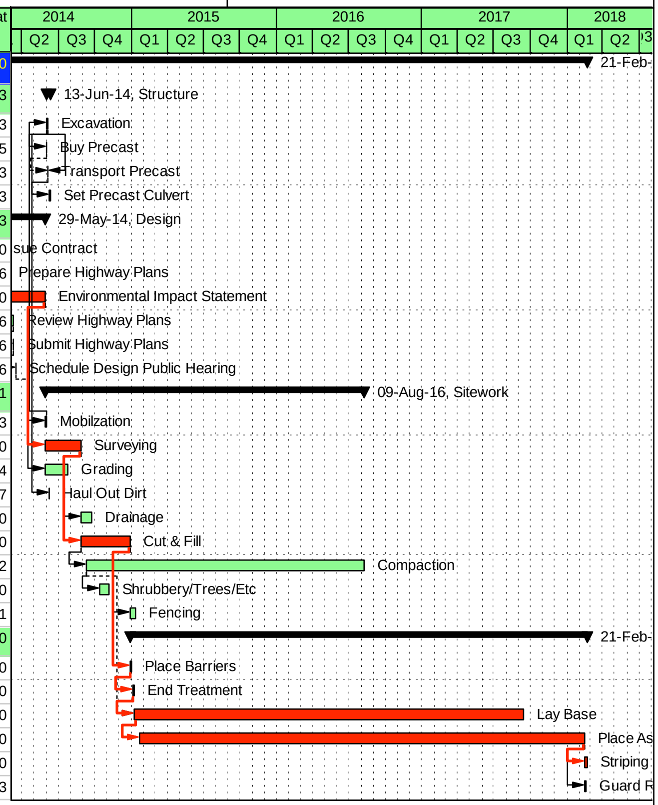


Appendix F – Construction



Capstone - Highway Widening Culvert		Classic WBS Layout			27-Nov-13 10:11

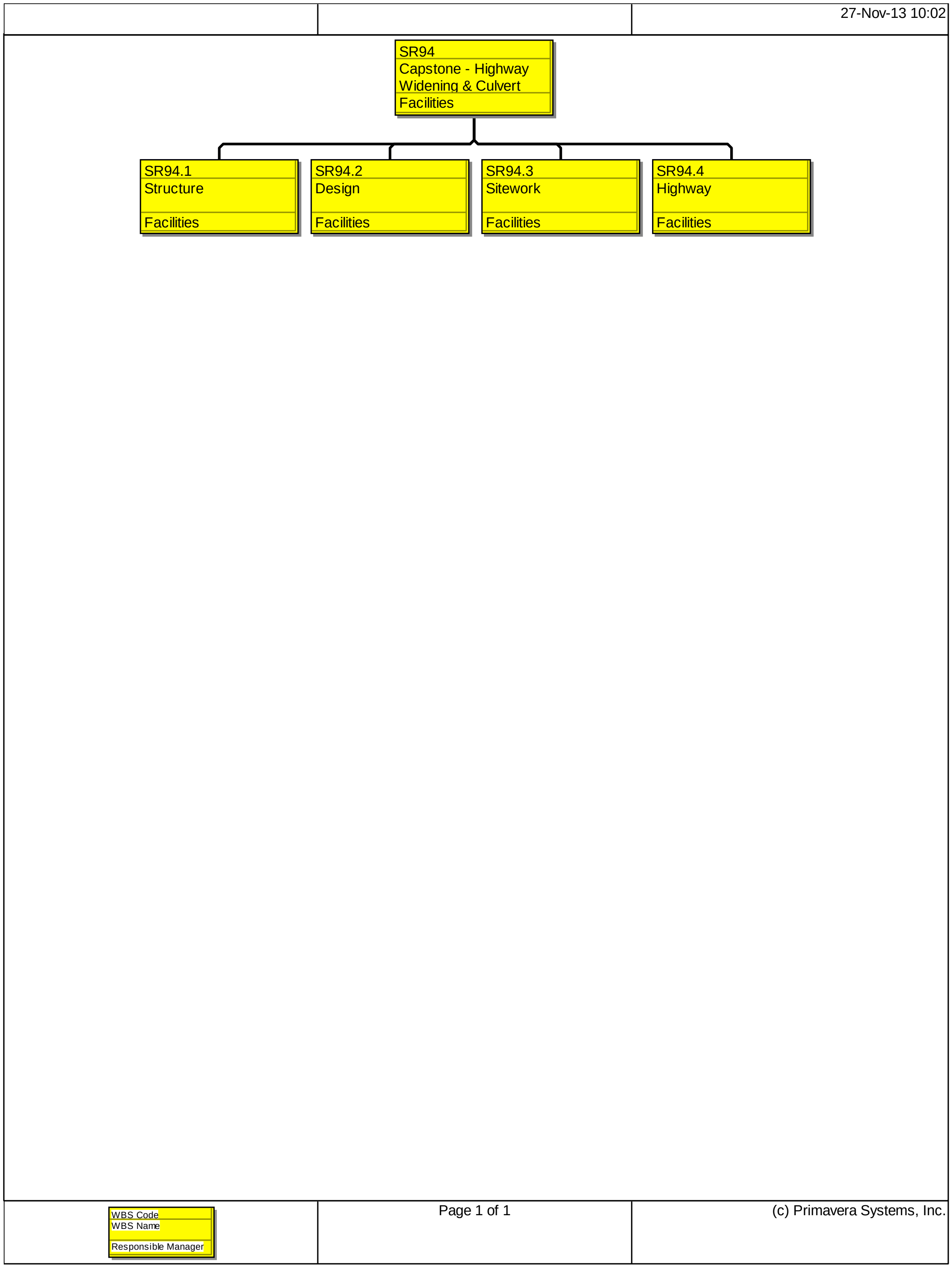
Activity ID	Activity Name	Original Duration	Start	Finish	Total Float
Capstone - Highway Wide		1078	06-Jan-14	21-Feb-18	0
Structure		9	03-Jun-14	13-Jun-14	963
SR1070	Excavation	4	03-Jun-14	06-Jun-14	963
SR1140	Buy Precast	1	03-Jun-14	03-Jun-14	965
SR1130	Transport Precast	1	06-Jun-14	06-Jun-14	963
SR1150	Set Precast Culvert	5	09-Jun-14	13-Jun-14	963
Design		104	06-Jan-14	29-May-14	963
SR1000	Issue Contract	1	06-Jan-14	06-Jan-14	0
SR1010	Prepare Highway Plans	30	07-Jan-14	17-Feb-14	1016
SR1005	Environmental Impact Stat	100	10-Jan-14	29-May-14	0
SR1020	Review Highway Plans	15	18-Feb-14	10-Mar-14	1016
SR1030	Submit Highway Plans	1	11-Mar-14	11-Mar-14	1016
SR1040	Schedule Design Public H	1	17-Mar-14	17-Mar-14	1016
Sitework		573	30-May-14	09-Aug-16	401
SR1060	Mobilzation	2	30-May-14	02-Jun-14	963
SR1100	Surveying	63	30-May-14	26-Aug-14	0
SR1110	Grading	40	30-May-14	24-Jul-14	934
SR1080	Haul Out Dirt	1	09-Jun-14	09-Jun-14	967
SR1120	Drainage	21	27-Aug-14	24-Sep-14	890
SR1160	Cut & Fill	90	27-Aug-14	30-Dec-14	0
SR1180	Compaction	500	10-Sep-14	09-Aug-16	72
SR1190	Shrubbery/Trees/Etc	16	15-Oct-14	05-Nov-14	860
SR1170	Fencing	10	31-Dec-14	13-Jan-15	811
Highway		821	31-Dec-14	21-Feb-18	0
SR1200	Place Barriers	3	31-Dec-14	02-Jan-15	0
SR1210	End Treatment	3	05-Jan-15	07-Jan-15	0
SR1220	Lay Base	700	08-Jan-15	13-Sep-17	0
SR1230	Place Asphault	800	22-Jan-15	14-Feb-18	0
SR1240	Striping	5	15-Feb-18	21-Feb-18	0
SR1250	Guard Rails	2	15-Feb-18	16-Feb-18	3



Actual Work | Critical Remaining Work | Summary
Remaining Work ◆ | ◆ Milestone

Page 1 of 1

TASK filter: All Activities


27-Nov-13 10:02
SR94
Capstone - Highway Widening & Culvert
Facilities
SR94.1
Structure
Facilities
SR94.2
Design
Facilities
SR94.3
Sitework
Facilities
SR94.4
Highway
Facilities
WBS Code
WBS Name
Responsible Manager
Page 1 of 1
(c) Primavera Systems, Inc.

Capstone - Highway Widening Culvert

Project Start 06-Jan-14
Project Finish 21-Feb-18
Data Date 06-Jan-14

Report Date 27-Nov-13 09:53

SR-01 Classic Schedule Report - Sort by ES, TF

Activity ID	Activity Name	Original	Start	Finish	Late Start	Late Finish	Free Float	Total Float	WBS	Successo	Predeces
SR1000	Issue Contract	1	06-Jan-14	06-Jan-14	06-Jan-14	06-Jan-14	0	0	SR94.2	SR1010, SR1005	
SR1010	Prepare Highway Plans	30	07-Jan-14	17-Feb-14	29-Nov-17	09-Jan-18	0	1016	SR94.2	SR1020	SR1000
SR1005	Environmental Impact Statement	100	10-Jan-14	29-May-14	10-Jan-14	29-May-14	0	0	SR94.2	SR1100, SR1110, SR1060	SR1000
SR1020	Review Highway Plans	15	18-Feb-14	10-Mar-14	10-Jan-18	30-Jan-18	0	1016	SR94.2	SR1030	SR1010
SR1030	Submit Highway Plans	1	11-Mar-14	11-Mar-14	31-Jan-18	31-Jan-18	0	1016	SR94.2	SR1040	SR1020
SR1040	Schedule Design Public Hearing	1	17-Mar-14	17-Mar-14	06-Feb-18	06-Feb-18	53	1016	SR94.2	SR1060	SR1030
SR1100	Surveying	63	30-May-14	26-Aug-14	30-May-14	26-Aug-14	0	0	SR94.3	SR1160, SR1120	SR1005
SR1110	Grading	40	30-May-14	24-Jul-14	28-Dec-17	21-Feb-18	934	934	SR94.3		SR1005
SR1060	Mobilzation	2	30-May-14	02-Jun-14	07-Feb-18	08-Feb-18	0	963	SR94.3	SR1070	SR1040, SR1005
SR1070	Excavation	4	03-Jun-14	06-Jun-14	09-Feb-18	14-Feb-18	0	963	SR94.1	SR1080, SR1140, SR1130	SR1060
SR1140	Buy Precast	1	03-Jun-14	03-Jun-14	13-Feb-18	13-Feb-18	2	965	SR94.1	SR1130	SR1070
SR1130	Transport Precast	1	06-Jun-14	06-Jun-14	14-Feb-18	14-Feb-18	0	963	SR94.1	SR1150	SR1140, SR1070
SR1150	Set Precast Culvert	5	09-Jun-14	13-Jun-14	15-Feb-18	21-Feb-18	963	963	SR94.1		SR1130
SR1080	Haul Out Dirt	1	09-Jun-14	09-Jun-14	21-Feb-18	21-Feb-18	967	967	SR94.3		SR1070
SR1160	Cut & Fill	90	27-Aug-14	30-Dec-14	27-Aug-14	30-Dec-14	0	0	SR94.3	SR1180, SR1170, SR1200	SR1100
SR1120	Drainage	21	27-Aug-14	24-Sep-14	24-Jan-18	21-Feb-18	890	890	SR94.3		SR1100
SR1180	Compaction	500	10-Sep-14	09-Aug-16	19-Dec-14	17-Nov-16	0	72	SR94.3	SR1220, SR1190	SR1160
SR1190	Shrubbery/Trees/Etc	16	15-Oct-14	05-Nov-14	31-Jan-18	21-Feb-18	860	860	SR94.3		SR1180
SR1200	Place Barriers	3	31-Dec-14	02-Jan-15	31-Dec-14	02-Jan-15	0	0	SR94.4	SR1210	SR1160
SR1170	Fencing	10	31-Dec-14	13-Jan-15	08-Feb-18	21-Feb-18	811	811	SR94.3		SR1160
SR1210	End Treatment	3	05-Jan-15	07-Jan-15	05-Jan-15	07-Jan-15	0	0	SR94.4	SR1220	SR1200
SR1220	Lay Base	700	08-Jan-15	13-Sep-17	08-Jan-15	13-Sep-17	0	0	SR94.4	SR1230	SR1180, SR1210
SR1230	Place Asphault	800	22-Jan-15	14-Feb-18	22-Jan-15	14-Feb-18	0	0	SR94.4	SR1240, SR1250	SR1220
SR1240	Striping	5	15-Feb-18	21-Feb-18	15-Feb-18	21-Feb-18	0	0	SR94.4		SR1230
SR1250	Guard Rails	2	15-Feb-18	16-Feb-18	20-Feb-18	21-Feb-18	3	3	SR94		SR1230

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