*Delta Vision*

# Context Memorandum: Transportation

This context memorandum provides critical information about transportation to support policy making. As they are developed, the context memos will create a common understanding and language about the critical factors in establishing a Delta Vision.

This is an iterative process and this document represents the beginning of a dialogue with you about how best to understand transportation and to inform recommendations by the Delta Vision Blue Ribbon Task Force. You have two weeks to submit comments that may be incorporated into the next iteration.

You may submit your comments in two ways: either online at dv_context@calwater.ca.gov or by mail. If you are using mail, please send your comments to: Delta Vision Context Memo: Transportation, 650 Capitol Mall, 5th Floor, Sacramento, CA 95814.

Your attributed comment will be posted on the Delta Vision web site (http:www.deltavision.ca.gov). Please cite page and line number with specific comments; general comments may be keyed to sections.

Your participation in this iterative process is valuable and important and is greatly appreciated. Thank you for your comments.

# Context Memorandum: Transportation

Iteration 1: June 28, 2007

## *Section 1. Policy Issues*

Key policy issues are:

- To what extent should transportation infrastructure be added in the Delta region to support the expected increase in transportation needs?

- How should regional land use management planning for the Delta and the Central Valley affect decisions for improving or expanding transportation systems?

- To what extent should islands that have transportation facilities or levees with roads on them receive special attention for additional levee protection?

- What alternatives to levee protection might be viable for key transportation features?

- How can the costs of transportation outages be minimized?

- What transportation planning and infrastructure and related communications planning might help to reduce costs of flooding and reconstruction following a levee failure event?

- How should waterways be integrated into regional transportation and emergency response planning?

The highways through the Delta provide important services, and are already very congested. The expected population growth in the region will add to this problem. Delta Risk Management Strategy (DRMS) economic analysis showed that, for islands that have roads or railroads, transportation lost use values can be large compared to other sectors. Additional highway infrastructure combined with increased use of alternative transportation options is planned. Three examples of the alternatives that are already developed or under consideration are:

- The use of pipelines to transport gasoline. The Kinder Morgan pipelines transport gasoline products across the Delta, thus reducing needed for tanker trucks on the Delta highways. However, these pipelines are at risk by scour during a levee break, and so as levees become less reliable the supplies of these products will be at increased risk. Protection and encouragement of such arrangements will reduce the need for additional highways. Currently the pipelines that cross the Delta serve both Northern California and Northern Nevada. It is expected that additional pipelines will be constructed from the

Southwest to provide alternative supplies to Nevada, allowing California to retain more of the gasoline products that use these pipelines. The provision of additional storage facilities to the east of the Delta would reduce losses that could occur as a result of pipeline disruption. However, these storage investment decisions are made by private distribution companies.

- The increased use of railways for short-haul and passenger service. Because the railways are privately owned, they may be more interested in retaining the use of their infrastructure for more remunerative long-haul shipping. Existing passenger service has minimized this concern by providing a subsidy equal to the fares collected from passengers. This increases the return to railways, while reducing the cost to passengers and thus increasing ridership. Increasing the use of railways in the Delta could also reduce the need for additional highways. However, once again the railways must be reliable if they are to contribute to the traffic solution, and railways must make sufficient investment in capacity to maintain or increase the level of goods shipped.

- The potential for barges and ferries from the Bay Area to Stockton and Sacramento to reduce the need for truck and car traffic on regional highways.

Despite these ambitions, the major transportation infrastructure continues to be the interstate highways and state highways through the Delta. Three key issues introduce difficulties to planning for the transportation system.

<u>Divided responsibilities:</u> The individual privately-owned railways develop their own, independent and proprietary plans for capacity expansion and utilization. Although the road system is planned by public agencies with open processes, planning and implementation of improvements in capacity or protection for existing roads is divided between federal, state and local agencies. Even within CALTRANS, responsibility for state roads within the Delta is spread across a number of CALTRANS districts. This division of responsibility makes a coordinated approach more difficult.

<u>Unclear responsibility for flood damages.</u> The 2003 “Paterno” decision found that when the State operated a flood control system built by someone else, it accepted liability as if it had planned and built it. The current litigation with BNSF involving the Jones Tract flood of 2004 may find the State liable for some flood damages to both government- and corporately-owned transportation infrastructure. This could be a disincentive for companies to invest in infrastructure that will minimize damages from a flood, and may pose risks to future state budgets.

Financing difficulties: Transportation infrastructure is capital-intensive, and the capital assets have long lives. This may affect an organization's willingness to invest in appropriate levels of capacity, because the costs are immediate and large, and the benefits more distant in time and less certain. Recently, concerns have been expressed about a nationwide perceived tightening of transportation capacity, and lack of strong evidence that sufficient investment will be made available to overcome this constraint. The lack of spending on highways, roads and bridges has long been a concern, with budget constraints leading to transportation funding being moved to other budget priorities. Relative to some other States, California is more able to issue State bonds to provide needed capital for transportation.

National organizations have recently expressed concern that the railroad industry is also reaching a point where capacity constraints will provide bottlenecks on the nation's transportation systems. According to a Congressional Budget Office Report (CBO 2006), the railroad system had been in a long run overcapacity condition before the Staggers Rail Act of 1980 removed some regulatory constraints and allowed railways to merge and rationalize the level of available capacity. Towards the end of this period of rationalization, rail freight traffic began to grow rapidly, with rail traffic increasing by 50 percent in the period 1990 through 2003. In 2004, the signs of capacity constraints in the rail system were so evident that the chairman of the Surface Transportation Board asked the seven major freight rail companies to explain their plans for increasing railroad capability. The capacity constraints of 2004 appear to have slackened in 2005, but long-term concerns remain about the ability and willingness of railways to invest in sufficient capacity to maintain their current share of freight transportation.

The Port of Sacramento has also expressed concern over funding. It does not expect to be able to fund proposed dredging of the ship channel from its own budget, and is seeking federal funding for this project.

## *Section 2. Scope and Background*

The Delta and areas protected by Delta levees include highways, railroads, and ship channels that link the Bay Area to the rest of the nation. Trucking and railways provide transportation to and from Bay Area ports in support of the growing international trade (FHA 2002, AASHTO 2003). The Delta transportation web provides the main link between the Bay Area and the Central Valley. This link provides transportation of agricultural inputs that support the Central Valley's agriculture, and transportation of agricultural produce from the Central Valley to markets in the Bay Area and beyond. In addition, the Delta transportation network provides a link between the Bay Area and the Central Valley's growing warehousing and storage facilities that provide supply support for Northern California and beyond. State Highway 12 is a major trucking link from the Tracy Army Depot to Travis AFB.

Several major interstate highways direct Bay Area traffic around the interior Delta, but several State highways through the Delta provide alternate routes to and from the Central Valley. While alternate routes to Southern California exist, a considerable amount of traffic from Northern to Southern California also uses Interstate 5. In addition to the roads of statewide importance, local roads allow a growing number of commuters to travel from their homes in the Central Valley to jobs in the Bay Area, and many local roads, ferries and bridges allow local traffic within the Delta.

The existing transportation systems through the Delta provide many alternative ways to move goods and people. In the short run, if transportation options are lost, higher cost alternatives would be relied on and there would be more congestion on alternate routes. If roads are closed suddenly by a flood there may be delays in delivery of products for consumption and export. In the long run, there may be opportunities to develop a more efficient regional transportation system that would be exposed to less risk associated with the Delta.

The Delta transportation system is critical to emergency response and reconstruction following a levee breach. A loss of roadways during a flood increases potential damages and loss of life. Many Delta roads occupy the levee crest so a levee breach will cause the road to be lost. Many roads depend on the use of ferries and bridges to cross channels. These crossings may be unable to operate during floods or high water. Emergency response should plan for the loss of roads and contingency plans for clearing waterways may help speed reconstruction.

The availability of roadways and waterways for reconstruction may determine the sequence of filling of levee breaches, dewatering and reconstruction following a multiple breach. These sequences will have a strong effect on the duration of lost use of Delta assets. Delta channels most likely will be used for moving construction equipment and reconstruction materials by barge. The availability of barges for reconstruction will also influence the duration of lost use.

The scope of this memo includes all transportation infrastructure – rail, roads and water transport - protected by levees located in the Delta:

1. All roads, including local streets, county roads, state highways, and interstate highways, and supporting infrastructure such as bridges and ferries;
2. All railways and supporting infrastructure;
3. All commercial shipping traffic and passenger services;

4. All airfields.

A map of the Delta showing major highways and roads is provided in Figure 1. Estimates of the economic value per day of major Delta transportation facilities based on disruption costs estimated for DRMS are provided in Table 1. The methods used to obtain these results are discussed in Section 5 below.

By the criteria of economic cost per day of outage these data suggest that some of the Delta roads are the most important transportation corridors in the region. The ports appear to be less important, but the cost of the outage could be increased if the assumed alternative of shipping by rail is not available. If rail freight were not available the cost of port outage would be increased to reflect the greater cost of shipping by road. If sufficient trucks and drivers are not available, the cost of all disruptions could be significantly higher than reported here.

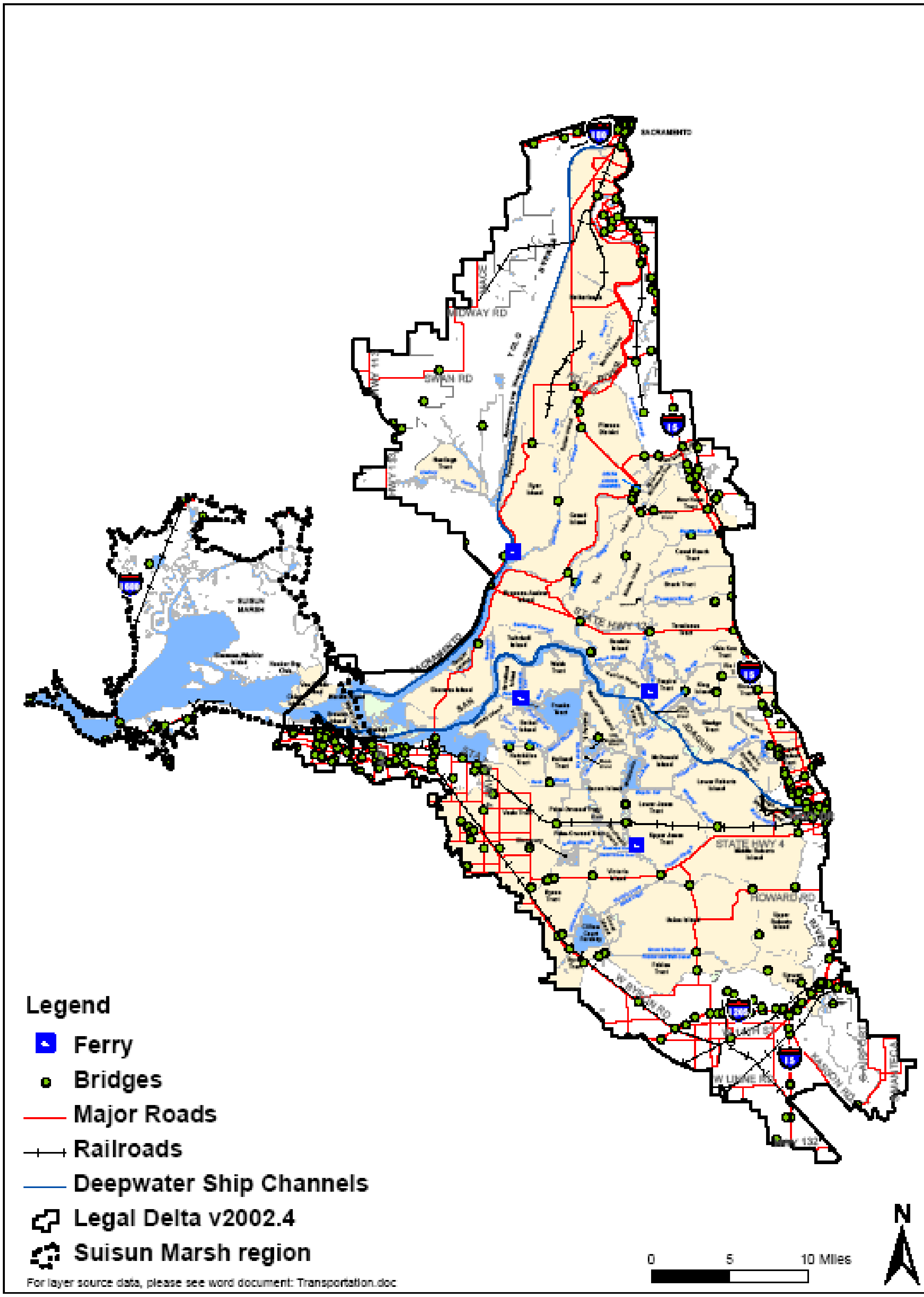
These results do not mean that additional investment in roads may be justified at the expense of other transportation modes. Such a finding would require a comparison of all economic costs and benefits of the alternative modes. Most of these expected costs and benefits would be large relative to the expected costs of an outage.

**Table 1.**
**Estimated Value per Day**
**for Delta Transportation Facilities Estimated for DRMS**

| Transportation Facility | Crosses which islands/tracts | Estimates of Economic Value per day, ($000) |
|---|---|---|
| Port of Sacramento | None | 2 |
| Port of Stockton | None | 10 |
| UP Railroad, Oakland to Sacramento | Suisun Marsh, Yolo Bypass | 800 |
| BNSF, Oakland to Stockton | Veale, Palm, Bacon, Jones, Roberts | 800 |
| UP, Fremont to Stockton | Pescadero, Stewart | 200 |
| Highway 160 | Sherman | 120 |
| Highway 4 | Roberts, Victoria, Byron | 500 |
| Highway 12 | Brannan Andrus, Bouldin, Terminous | 300 |
| Interstate 5 | East side of the Delta from Lathrop to Sacramento | 3,000± |
| Interstate 680 | Suisun Marsh | Unknown |
| Interstate 80 | West Sacramento, Sacramento | Unknown |
| Interstate 205 | Pescadero, Stewart | 4,000± |

Note: Values are costs to transport by alternative mode or route under 2005 conditions. They are not additive because of possible interactions. Daily values are affected by assumptions regarding congestion costs and the presence of alternate routes.

**Figure 1.**
**Map of the Delta Transportation Network**



More detailed discussion of the transportation infrastructure is provided below.

**Roads**

CALTRANS provides data on average annually daily traffic (AADT) for state and federal highways (CALTRANS 2006). The data are provided as traffic flows in both directions on each side of specified points on the highway. Table 2 shows each road analyzed, the region that each road crosses, and the 2005 AADT on each. Figure 2 provides a schematic of traffic volumes over major Delta roads. Differences in AADT along a road segment are caused by additions and subtractions at important population centers and connecting routes.

Table 3 shows the 2004 share of traffic that was truck traffic on some important Delta highways. There are important differences among Delta highways with respect to their importance for trucking. Truck traffic makes up about 5 percent of traffic on Highways 220 and 160, but 25 percent of traffic on Interstate 5, and large trucks are an important share of the total.

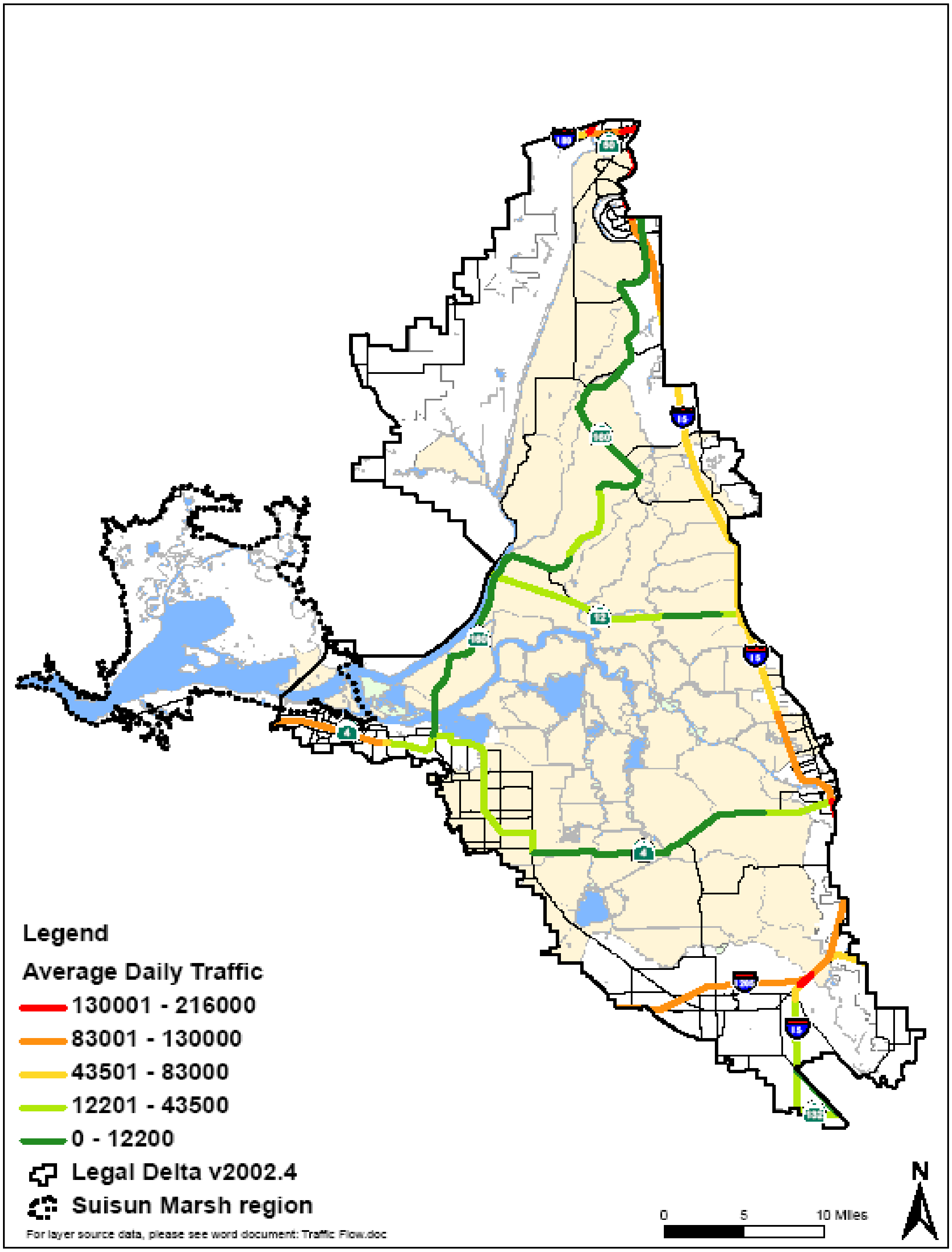
**Table 2**
**Major Roads in the Delta, Locations, and Reported Traffic Loads**

| Highway | Location | Reported AADT |
|---|---|---|
| I-5 | Glanville Tract, New Hope, Canal, Brackt, Terminous, Shin Kee, Rio Blanco, Bishop, Shima, Sargent Barnhart 2, Wright-Elmwood Sargent Barnhart, other areas in Sacramento and Stockton | 57,000 to 188,000 |
| I-5/205 | Stewart Tract, Pescadero | 160,000 |
| I-80 | West Sacramento | 81,000 to 240,000 |
| I-680 | Benicia to Cordelia | 62,000 to 69,000 |
| 220 | Ryer, Grand Islands | 120 to 880 |
| 160 | Sherman Island | 2,800 to15,000 |
| 84 | Netherlands | 130 to 2,900 |
| 12 | Brannan Andrus, Bouldin, Terminous Tract 2, Terminous Tract 1 | 15,700 to 21,700 |
| 4 | Roberts, Victoria, Byron (Tracy Blvd. To Stockton, Navy Dr.) | 9,900 to 12,200 |
| J2 | Union Island | No data |
| J11 | Tyler Island, Staten Island, New Hope Tract | No data |
| E13 | Pierson District, Glanville Tract | No data |
| E9 | Merritt Island, Netherlands | No data |

**Table 3.**
**2004 Average Annual Daily Traffic and Average Annual Truck Traffic for Selected Delta Locations**

| Route Number | Location | Average Annual Daily Traffic | AADT Trucks | AADT Trucks, 5+ axles | Percent Truck Traffic | Percent 5+ Axle Truck Traffic |
|---|---|---|---|---|---|---|
| 4 | JCT. RTE. 160 | 40,500 | 2,175 | 889 | 5.4% | 2.2% |
| 4 | TRACY BOULEVARD | 8,400 | 966 | 581 | 11.5% | 6.9% |
| 4 | ROBERTS ISLAND ROAD | 10,500 | 1,385 | 825 | 13.2% | 7.9% |
| 5 | JCT. RTE. 205 WEST | 147,000 | 38,808 | 31,046 | 26.4% | 21.1% |
| 5 | STOCKTON, JCT. RTE. 4 | 123,000 | 30,135 | 23,807 | 24.5% | 19.4% |
| 5 | JCT. RTE. 12 | 74,000 | 11,640 | 8,319 | 15.7% | 11.2% |
| 5 | WALNUT GROVE ROAD | 50,000 | 12,170 | 8,698 | 24.3% | 17.4% |
| 5 | SACRAMENTO, POCKET/MEADOWVIEW RDS | 105,000 | 13,871 | 9,913 | 13.2% | 9.4% |
| 12 | JCT. RTE. 160 | 15,100 | 2,190 | 1,351 | 14.5% | 8.9% |
| 12 | SACRAMENTO/SAN JOAQUIN County Line | 15,700 | 2,214 | 1,441 | 14.1% | 9.2% |
| 12 | JCT. RTE. 5 | 12,800 | 1,958 | 1,259 | 15.3% | 9.8% |
| 160 | ANTIOCH, JCT. RTE. 4 | 12,600 | 1,652 | 731 | 13.1% | 5.8% |
| 160 | JCT. RTE. 12 | 14,200 | 1,321 | 873 | 9.3% | 6.1% |
| 160 | SACRAMENTO RIVER, Isleton Bridge | 2,800 | 157 | 68 | 5.6% | 2.4% |
| 160 | WALNUT GROVE, WALNUT Grove Bridge | 2,700 | 197 | 111 | 7.3% | 4.1% |
| 160 | FREEPORT BRIDGE ROAD | 6,400 | 192 | 19 | 3.0% | 0.3% |
| 205 | JCT. RTE. 580; BEGIN FREEWAY | 111,000 | 15,762 | 11,096 | 14.2% | 10.0% |
| 220 | JCT. RTE. 84 | 120 | 4 | 0 | 3.3% | 0.0% |
| 220 | RYDE, JCT. RTE. 160 | 750 | 47 | 10 | 6.3% | 1.3% |

**Figure 2. Average Annual Daily Traffic on Select Roads in the Delta**



# Context Memorandum: Transportation

Iteration 1: June 28, 2007

**Railways**

Three major railways cross the Delta. These railways carry freight and passenger service. The railways are described below.

**The Union Pacific Railroad from Oakland to Sacramento.** This railway carries both freight and the Capital Corridors passenger service. The line is potentially susceptible to disruption because of flooding in two reaches: in Suisun Marsh from Suisun City to Benicia, and in West Sacramento and Sacramento. Some of this line is located in marshy areas that can become waterlogged and cause mechanical problems. A derailment in 2003 and a subsequent improvement program disrupted traffic for months.

The passenger service is estimated to consist of 32 intercity (San Jose to Sacramento and return) trains plus four long-distance trains per day. This is an estimated total of 325 cars per day, with 1.3 million passengers per year. The service is estimated to reduce travel on the road between San Jose and Sacramento by 100 million vehicle miles per year. Capitol Corridors is the managing agency, and obtains 50 percent of its funding from the state, with a further 50 percent obtained from fares paid (Skaoropowski 2006). The annual revenues are approximately $16 million, or $43,000 per day. The on-time record for this line can be adversely affected by the operation and dispatching of freight traffic. In addition, this line also serves the San Joaquin intercity trains  as well as Amtrak connections between Los Angeles and Seattle and between Oakland and Chicago.

The freight service ships a mixture of automotive and intermodal[1] service (ship to train) from ports in the Bay Area. There are approximately 17 trains per day, with 75 to 100 cars per train (Wickersham, 2006). This amounts to approximately 1500 box cars per day.

**The Union Pacific Railroad from Fremont to Stockton.** This railroad is susceptible to flooding in Pescadero, Stewart Tract and RD 17. It carries 11 trains per day. Six of these are passenger, and 5 are freight. The freight service ships automobiles from the Fremont New United Motor Manufacturing Inc. (NUMMI) plant, other automobile, intermodal container freight, and other general freight (ibid). The volume of traffic is roughly 500 railroad cars per day. Passenger service is provided by the

[1] Intermodal service refers to miscellaneous goods that are packaged together, such as containerized maritime cargo or truck trailers that are loaded on and offloaded from railroad cars in that form.  This is higher value rail freight, and the fastest growing form of rail freight (CBO 2006).  The automotive shipments include imports through the Port of Benicia.  For example, Toyota vehicles are imported through Benicia for supply to Arkansas, Mississippi, Oklahoma, Texas and parts of California (Autochannel 2005)

Altamont Commuter Express (ACE). Four trains run each way weekdays except holidays.

**The Burlington Northern Santa Fe (BNSF) Railroad to Stockton.** This line runs through the primary Delta between Palm and Orwood Tract, between Bacon and Woodward Tracts, and through Jones Tract and Roberts Island. Because of current litigation involving the Jones Tract flood of 2004, current data on freight volume is not available to DWR. Amtrak also operates an intercity passenger service on this railroad. The passenger service runs between Oakland through Port Chicago to Stockton. There are 8 passenger trains (4 round trips), with annual farebox revenues of $27 million, and a similar amount from the state (Bronte, 2006). These revenues are $146,000 per day.

The BNSF railway traverses the Delta and Suisun Marsh on an east and west route between Stockton and Interstate 780. The other railways are generally around the periphery of the Delta. During the Jones Tract flood, service on this line was completely interrupted for a short time and speeds were severely reduced for months because of concerns about waterlogged embankments and water action.

**Commercial Boat Traffic and Ports**

Commercial boat traffic includes freight traffic through the Ports of Stockton and Sacramento, ferries which are used to carry vehicle traffic across Delta channels, and a variety of boat traffic for local commercial and tourism purposes. This category does not include any recreation boat traffic or commercial operations for the pleasure boat market such as marinas and boat rentals (see Recreation Context Memo).

The two commercial shipping channels: Sacramento Deep Water Channel and Stockton Deep Water Ship Channel, provide important routes for freight transportation. Data on recent tonnage is provided by the California Association of Port Agencies. Recent volume was 0.7 and 2.9 million metric tons in Sacramento and Stockton, respectively (CAPA, 2005).

In Stockton, the largest shares of products recently shipped in order of weight were cement, fertilizer, rice, anhydrous ammonia, molasses, bridge segments, and steel products. Inbound trading partners in order of weight received were Thailand, Indonesia, China, Taiwan and Canada. Important outbound partners were Japan, China, Brazil, and the Bay Area (Port of Stockton 2005). In 2006 China became the most important inbound and outbound partner. Total revenues exclusive of property management in 2005 were $14.2 million; this increased to over $18 million in 2006.

# Context Memorandum: Transportation

Iteration 1: June 28, 2007

**Air transportation**

Air transportation is limited to small private airstrips and agricultural chemical applicators. There are several small and private strips, primarily for local use. Delta Protection Commission (DPC) policy is not to expand or add new general aviation airports in the Primary Zone. The potential implications of alternative Delta policy options for air transportation in the region are believed to be minimal.

## *Section 3. Trends and Issues*

Use of area highways is expected to continue expanding with population. In the longer future, higher fuel costs and better transportation alternatives could reduce highway traffic. The recent trend in traffic is primarily related to regional growth in the Central Valley, where population is expected to continue growing faster than the State as a whole.  CALTRANS information on historic trends in traffic movements shows that during some decades in the past, regions near the Delta have experienced travel growth of more than 60 percent. Statewide, vehicle miles of traffic are forecast to increase 25 percent in the decade of 2000 to 2010, and 23 percent to 2020 (CALTRANS, 2003).

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) strengthened planning practices and coordination between States and metropolitan areas and between the private and public sectors. Metropolitan Planning Organizations (MPOs) must develop a transportation plan for a 20-year period and identify facilities (including roadways, transit, and intermodal facilities) that should function as an integrated regional system. The MPOs establish long-range priorities for their transportation system through the development of a Regional Transportation Plan. Land use and transportation planning must be linked. Several regional agencies have jurisdiction over parts of the Delta including the Sacramento Area Council of Governments, the San Joaquin Council of Governments, and the Metropolitan Transportation Commission. These agencies also oversee distribution of federal highway funds and maintain demand models used for their plans (See, for example, MTC 2006).

CALTRANS develops inter-regional transportation plans (CALTRANS 2004). California transportation funds and most of the federal transportation funds made available under Title 23 are programmed through the five-year biennial Statewide Transportation Improvement Program (STIP) and the four-year biennial State Highway Operations and Protection Program (SHOPP). Through this process, regional demands and priorities become programmed highway projects.

In general, increasing freight traffic for rail and ports is expected, primarily related to international trade. International trade volumes are continuing to increase as production and trade adjust to international trade agreements and comparative advantage. The Metropolitan Transportation Commission forecasts that container traffic tonnage at San Francisco area ports (largely Oakland and Richmond) is expected to increase by 5 percent per year through 2030 (MTC 2004), supporting increasing loads for the railways crossing the Delta.

The passenger train routes are continuing to grow as population growth moves out of the Bay Area into surrounding counties. These services are expected to continue to grow, but continued public funding will be required.

Highway congestion, coupled with the movement of warehousing and trucking operations to the Central Valley, has prompted planning for short-haul rail services that would use existing rail assets to link the Port of Oakland to those trucking locations (the California InterRegional Intermodal System, or CIRIS, Tioga 2006a). However, the Bay Area section of the state's Goods Movement Action Plan concentrates largely on improving highway traffic flows. In this plan, the majority of rail investments are projected for the Los Angeles area. The Sacramento Area Council of Governments forecasts that rail cars into and through Sacramento will grow by 1.9 percent per year from 2003 through 2020 (Tioga, 2006b).

In contrast to these growth forecasts, the Port of Sacramento has seen an average decline in tonnage since 1994. This is related to reductions in agricultural and forestry shipments, which were the mainstay of operations at the port. The port also operates with several handicaps. The shipping channel to the port had been dredged to 30 feet deep, five feet less than the Stockton shipping channel. The port's area is constrained by the surrounding city of West Sacramento, so it has limited ability to expand to support increased containerization of cargoes. It also has a less extensive nearby production and market area to support the port than is the case in Stockton. The Port of Sacramento competes with the Port of Stockton and the more efficient Bay Area ports. These ports are able to accept a broader range of cargoes that can be transported in and out of the Sacramento area more cheaply and quickly by truck and rail than by shipment through the Port. However, the port of Oakland has taken an interest in the Sacramento port. They have recently added two terminals for cement and concrete transportation, and are developing plans to seek funding for increasing depth of the channel (Tioga, 2006b).

The Port of Stockton has many advantages over the Port of Sacramento, including a deeper shipping channel. In addition, the port obtained facilities and land on Rough and Ready Island from the Navy through the military's base closure process. Cargo levels through the port have continued to grow, and in 2005 Stockton became the fourth busiest port in California, after Los Angeles, Long Beach and Oakland. Stockton's position near the growing warehousing and distribution centers of the Central Valley is also seen as an advantage (Port of Stockton, 2005).

Both ports are currently investigating the use of barges to move goods between California's coastal ports and the Central Valley. It is too early to say whether this will be successful, but the Port of Stockton reports strong growth in barge traffic in 2005.

## *Section 4. Conceptual Models*

Conceptual models for transportation include demand models, network modeling and traffic flow modeling. Demand models predict potential usage by large populations, networks represent route systems, and traffic flow modeling combines information on demand, networks and features of the available routes to estimate usage by route. Resulting models are used for planning purposes, and economic models can be used to calculate the costs of outages or the benefits of improvements.

**Demand Models.** Demand models are concerned with the relationship between demographic and economic factors and demand for transportation services. Econometric models are often used to show how changing factors such as incomes and transportation costs will affect demand. CALTRANS uses the Motor Vehicle Stock, Travel and Fuel Forecast Model, an econometric model, to predict demand (Jones, 1998). Regional transportation planning agencies often have their own demand modeling capabilities.

**Planning Models.** Planning models are used to evaluate how system improvements and demand changes will affect system performance. The California Integrated Transportation Management System (ITMS), discussed below, includes a number of performance measures.

**Economic models of outages.** The existing transportation infrastructure in the Delta is prone to flooding as a result of levee failure, and local flooding can close roads during severe storms. This is discussed in the Infrastructure Technical Memorandum of the DRMS report. Travel cost modeling is discussed in the Economic Impacts Technical Memorandum of the DRMS report and in Section 4 below.

Lost use costs consist of increased travel time and costs for traffic that must be re-routed, lost value of trips for some travelers who do not travel or who travel somewhere else instead, increased congestion costs for all travel that would use the alternative routes even without the flood event, and other business costs.

Factors affecting lost use costs include the following:

**The duration of the outage**: Whether caused by flood or reconstruction, any actions to reduce the duration of the outage will decrease costs.

**Substitution opportunities and costs:** Economic costs of lost transportation services depend on the quality of alternative transportation modes and routes. There are alternative routes available in the region, but they are already subject to congestion costs. There are also a number of modes for transportation, including pipelines, railroads, trucks and cars, barges and other vessels. These alternative modes can at least partially substitute for any failure of other transportation sectors.

**Adjustment and learning:** Daily economic costs will be affected by the response of transportation users to the event; in particular, their choice of alternate routes. This choice may be affected by congestion conditions. The process of learning and adjusting may take time and will be affected by the quality of information provided by private and public sources.

**Congestion costs:** Congestion costs in the future will depend on roadway and other transportation improvements, and the response of traffic patterns to changes in work and leisure patterns and price signals such as the cost of gasoline and the required reduction in greenhouse gases. Congestion costs can occur in transportation modes not directly affected by an event. With interactions across modes, congestion costs cause by port closures may spread to rail and road, and congestion costs of rail closures may spread to roads.

**Price increases:** Lost use costs may be affected by price increases caused by an event. These price increases may reflect real increased marginal costs of providing services; for example, overtime labor, costs of getting additional trucks to the region, or use of more inefficient trucks. There is no empirical information from the region to suggest the magnitude of price increases that might be expected. Price regulations for some transportation modes could result in shortages.

**Lost trips:** Some trips may be foregone or delayed by the loss of a transportation route. However, not all trips lost to the region are lost to the State. For example, vacation trips lost to the region may be replaced by trips taken to other regions of the State or nation. Some commercial traffic may be delayed if storage is available at the area of origin. All of these effects have an economic cost, but this cost is not the same as the lost trip cost. On the other hand, lost trips represent a decrease in total regional traffic and, all else equal, reduce costs of congestion caused by an event.

**Other business costs:** Other business costs include economic costs to ultimate buyers of goods and services whose delivery is delayed by the lack of transportation infrastructure.

## *5. Evaluation Tools*

There are two key types of tools to evaluate proposed changes in transportation infrastructure and policy. The first is a high level tool to evaluate proposed changes in transportation, and the second could be used to evaluate changes in risks to transportation infrastructure.

**Integrated Transportation Management System.** CALTRANS has developed a software tool that provides a broad-brush approach to multimodal transportation planning, known as the California Intermodal Transportation Management System (ITMS). This system models demand and supply for passenger and freight transportation on a statewide basis. This model allows the user to enter proposed policy or infrastructure changes that are under consideration, and the model uses demand models and actual transportation data to develop performance measures that allow evaluation of the proposed changes to the transportation system.

The evaluation measures are developed for baseline and a proposed scenario, to assist the analyst in determining whether a specific proposal provides sufficient benefits to justify its adoption. The evaluation measures reported are as follows:

**Personal Travel Market**

Changes to this market are evaluated through the following metrics:

- Change in mobility index
- Lost time due to congestion
- Cost to service providers
- Cost to travelers
- Changes in pollutants.
- Changes in fuel consumption
- Changes to greenhouse gases
- Additional jobs supported and gross area product changes.
- Safety measures, including daily accidents, deaths and injuries.

**Freight and Goods Movement**

Changes to this market are evaluated through the following metrics:

- Changes in Freight throughput
- Lost time due to congestion
- Cost to users

- Changes in pollutants
- Changes in fuel consumption
- Changes to greenhouse gases
- Additional jobs supported and gross area product changes.
- Safety measures, including daily accidents, deaths and injuries

(CALTRANS 2001).

**Algorithms to measure the benefit of risk reduction.** Because of the risks of flood and earthquake in the Delta, it would also be useful to evaluate the reduction in risk to the transportation system from proposed changes, such as strengthening levees and developing hardened infrastructure corridors.

The economic analysis of the transportation infrastructure in DRMS was focused on the short-run costs of lost use of the infrastructure. Two models were used; REDARS, a model developed for analysis of earthquake events for CALTRANS, and a simplified quadratic programming model.

***Roads:*** A software system developed for CALTRANS estimates the costs of lost use of highways. The Risks from Earthquake Damage to Roadway Systems (REDARS) software and database can be used to estimate the changes in travel cost resulting from road closures. Although developed to investigate earthquake concerns, it is equally applicable to any form of road closure. The package uses a national database of road system information to design a model that calculates increased use costs and lost trip costs associated with road system disruptions. This model was used to estimate lost use costs for some combinations of roadway disruptions for the DRMS study. However, running this model is time-consuming, so its use was limited to a few of many possible scenarios. To develop the costs of rerouted journeys and increased congestion, REDARS assumes a cost of $13.45 per hour for automobile trips and $71.05 per hour for truck trips.

In addition, a model of the Delta highway system developed for DRMS is available. This quadratic programming network model represents traffic flows as equations. The model uses average annual daily traffic (AADT) data from CALTRANS to establish initial conditions. For each highway, an average speed is assumed for the baseline condition, and the model adopted a FEMA cost estimate of $32.23 per hour of additional travel time caused by a road outage. With speed, AADT and the cost per hour, baseline costs of travel can be derived. Then, when a disruption scenario is assumed to remove one or more of the links from the model corresponding to a road or roads that are closed, the model reroutes the traffic to the least-cost combination of alternative roads that are still open.

# Context Memorandum: Transportation

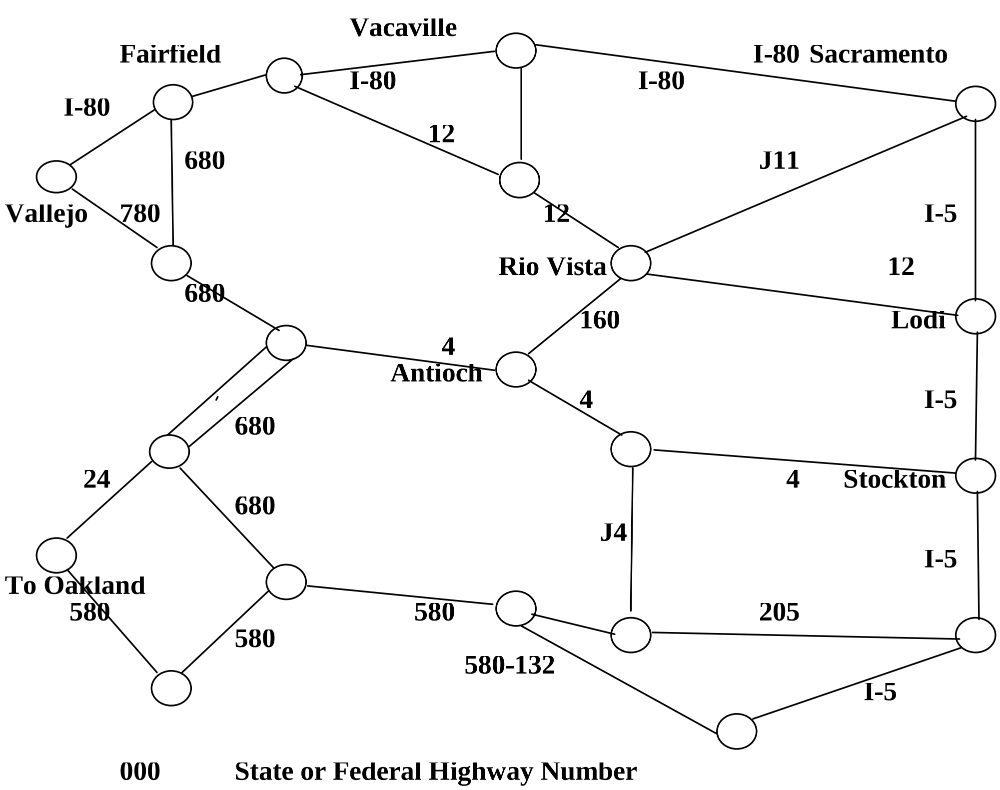
Iteration 1: June 28, 2007

To model congestion, the model assumes that average speed is a function of traffic volume. It is assumed that the relationship between speed and traffic volume is linear such that average speed would be reduced to zero at a traffic volume of five times the current level. When roads are assumed closed and traffic is diverted to least cost alternate routes, the cost per vehicle also increases as average speed is reduced.

A diagram of the simplified model is provided as Figure 3.

***Railways and Ports:*** For both of these transportation modes, the DRMS analysis based the estimated cost of infrastructure disruption on the increased costs associated with substitute transportation modes. The value per day of the two ports, based on increased cost of transportation by rail, was estimated to be approximately $2,000 per day for the Port of Sacramento and $10,000 per day for the Port of Stockton. These values assume that rail capacity is available and able to take the freight. For railways the daily values were estimated to be approximately $800,000 per day each for the UP railroad to Sacramento and the BNSF railroad to Stockton, and $200,000 for the UP railroad to Stockton.

**Figure 3. Network Diagram for DRMS Traffic Quadratic Programming Model, Not to Scale**



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