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Yolo Bypass Water Quality Management Plan Report

Prepared under CALFED Watershed Grant, Agreement # 4600001691

For the City of Woodland

Prepared by:

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EXECUTIVE SUMMARY

The Yolo Bypass ("Bypass") is a leveed, 59,000-acre floodplain, approximately 41 miles long and 1-3 miles wide, parallel to and on the west side of the lower Sacramento River in California's Yolo and Solano Counties (Figure ES-1). The major flood control features are the Fremont and Sacramento Weirs, over which floodwaters in the Sacramento, Feather, and American Rivers spill. Other major inputs to the Bypass include, from north to south, the Knights Landing Ridge Cut, Cache Creek, Willow Slough, and Putah Creek. Urban stormwater runoff and wastewater treatment facility discharges come from the University of California Davis campus and the Cities of Davis, Woodland, and West Sacramento (stormwater only).

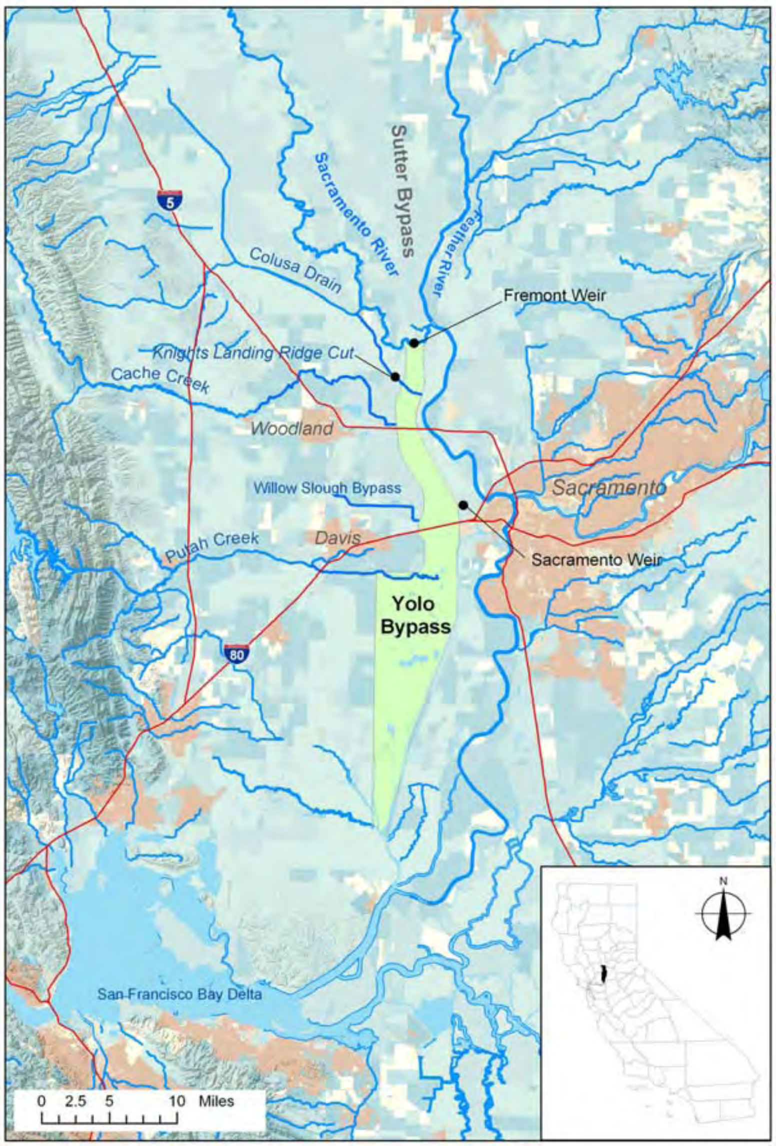

Figure ES-1. Location of the Yolo Bypass with its major tributaries.

The Bypass is a vital flood control feature that protects low-lying areas in the Sacramento area. In addition, it receives water from local drains and creeks, and urban stormwater and wastewater. Water is used beneficially within the Bypass in several ways, most notably agriculture and wildlife habitat. Discharges to the San Francisco Bay-Delta also contribute to regional drinking water supplies.

The objective of this project was to develop a comprehensive water quality management plan for the Bypass. The general steps followed to develop the plan were to:

- Identify through review of existing information and stakeholder input current pollutants of concern (POCs) for the Bypass;
- Conduct surface water quality monitoring to help quantify POCs and their major sources;
- Identify and evaluate effective, implementable control measures for reducing POC concentrations and loads;
- Investigate, if necessary, the applicability of current water quality criteria for the POCs and the feasibility of developing site-specific objectives (SSOs);
- Involve stakeholders regarding POCs and potential control measures;
- Produce a Water Quality Management Plan containing a recommended implementation program to address POCs that are degrading surface water quality.

The POCs were identified by stakeholders after a cursory review of available data. The identified POCs were then monitored over a one-year period. Based on these monitoring results and stakeholder input, the POCs were prioritized as shown in Table ES-1.

Table ES-1. Prioritization of the POCs.

POC	Priority		
	High	Medium	Low
Bacteria	X		
Total coliform			
Fecal coliform			
E. coli			
Boron	X		
Metals			
Aluminum	X		
Chromium			X
Copper			X
Lead			X
Mercury	X		
Selenium			X
Nitrate			X
Organic Carbon		X	
Total organic carbon			
Dissolved organic carbon			
Pesticides and Herbicides			
OCs (DDE and DDT)		X	
OPs (Chlorpyrifos and Diazinon)		X	
Carbamates (Diuron and Methomyl)			X
Salinity	X		
Total Suspended Solids (TSS)			X

The goal of this plan is to set forth a series of actions that will result in achievement of water quality objectives appropriate for the Yolo Bypass. The most stringent, potentially applicable water quality objectives found in the Basin Plan, local NPDES permits, and proposed Basin Plan amendments are the basis of the objectives compared with monitoring data. Potential options for addressing the POCs to meet those objectives are as follows, generally in order of most preferable first.

- Implement control measures. Implement feasible and cost-effective control measures such as described previously in this report.
- Undertake research and special studies. Conduct focused studies that improve the conceptual model for certain POCs or that aid in quantifying effectiveness of control measures.
- Monitor water quality. Monitor water quality to improve our ability to detect changes in water quality and to quantify linkages in the conceptual models for various POCs.
- Conduct site-specific objective or beneficial use studies. Address POCs coming from predominately natural and uncontrollable sources.
- Participate in future stakeholder activities. Participate in related stakeholder forums and in the development of plans and policies that directly impact water quality in the Bypass.

The resulting plan provides an adaptive management framework in which some recommended actions aim to reduce POC loads while others would provide for additional information for improving our ability to effectively manage water quality in the Bypass. Actions described under these options address all high and medium priority POCs. Future stakeholder activities are also recommended to foster collaboration and participation as information improves the ability to manage water quality.

TABLE OF CONTENTS

Section — Page

Executive Summary ... i
Table of Contents ... iv
List of Acronyms ... xi
Acknowledgements ... xii
Stakeholders Advisory Group Participants ... xiii
Introduction ... 1
- Goals and Objectives of the Project ... 2
  - Stakeholder Process ... 4
  - Identification of POCs ... 5
  - Support for CalFed Watershed Program and Coordination with Other Programs ... 6
- Regulatory Framework ... 6
  - Basin Plan Beneficial Uses ... 6
  - Most Restrictive Potentially Applicable Water Quality Criteria ... 7
  - List of Impaired Waters and TMDL Status ... 10
  - NPDES Permits ... 10
  - Waivers from Waste Discharge Requirements ... 11
  - 404 Corps of Engineer Permits ... 12
  - Streambed Alteration Agreements (California Fish and Game Code 1600 et seq.) ... 12

Environmental Setting ... 13
- Hydrology and Water Resources Management ... 13
  - Major Tributaries to the Yolo Bypass ... 14
  - Permitted Wastewater Dischargers ... 16
  - Permitted Stormwater Dischargers ... 16
  - Agricultural Irrigation ... 16
  - Water Withdrawals from the Bypass ... 17
- Land Uses ... 17
  - Land Uses in the Yolo Bypass Watershed ... 17
  - Land Uses in the Yolo Bypass ... 20

Monitoring Program ... 21

Description of Monitoring Stations 21
Sampling and Analysis Methods 24
Quality Assurance Program Plan 24
Site Observations 24
Field Measurements 24
Water Column Samples 24
Streambed Sediment Samples 24
Sampling Schedule and Review of Monitoring Events 25
Summary of Monitoring Results 27
Water Column Samples 27
Streambed Sediment Samples 27
Flow Rate Estimates 27
Assessment of Current Water Quality 29
Bacteria 31
Spatial Patterns 31
Temporal Patterns 31
Conceptual Model 31
Boron 32
Spatial Patterns 32
Temporal Patterns 32
Conceptual Model 33
Aluminum 33
Spatial Patterns 33
Temporal Patterns 34
Conceptual Model 34
Mercury 34
Spatial Patterns 34
Temporal Patterns 37
Conceptual Model 38
Other Metals 41
Spatial Patterns 41
Temporal Patterns 41
Conceptual Model 41

Nitrate 41
Spatial Patterns 41
Temporal Patterns 41
Conceptual Model 41
Organic Carbon 42
Spatial Patterns 42
Temporal Patterns 42
Conceptual Model 42
Pesticides 42
Spatial Patterns 43
Temporal Patterns 44
Conceptual Model 44
Salinity 44
Spatial Patterns 44
Temporal Patterns 45
Conceptual Model 45
Total Suspended Solids 46
Spatial Patterns 46
Temporal Patterns 46
Conceptual Model 46
Prioritization of POCs 46
Potential Control Measures for High and Medium Priority POCs 48
Conduct General Outreach and Education 50
Reduce Local Groundwater Use 51
Improve Source Water Quality 51
Reduce Urban Water Demand 53
Reduce POTW Influent Loads 53
Encourage Alternatives to Conventional Water Softeners 54
Outreach on Proper Operation of Water Softeners 55
Conduct Mercury-specific Outreach and Education 55
Enhance Industrial Pretreatment 56
Enhance POTW Treatment 57
Install Tertiary Treatment 57

Install Microfiltration – Reverse Osmosis ... 58
Improve Urban Storm Water Management ... 59
Minimize Effects of New Development ... 60
Outreach to Minimize Stormwater Impacts ... 60
Improve Rural Land and Water Management ... 61
Construct or Improve Settling Basins ... 62
Enhance IPM Programs ... 63
Enhance Irrigation Water Management ... 64
Optimize Pesticide Applications ... 65
Restrict or Change Pesticide Use ... 65
Minimize Erosion and Sediment Transport to Waterways ... 67
Remove or Stabilize Mine Waste ... 69
Manage Water Resources for Water Quality Benefits ... 70
Minimize POTW Discharges to the Bypass ... 70
Manage Water Use in Bypass Wetlands ... 71
Alter Inter-basin Water Transfers ... 72
Water Quality Management Plan ... 74
Implement Control Measures ... 75
Improve Source Water Quality ... 75
Conduct Outreach and Education ... 76
Implement Agricultural BMPs ... 76
Implement Livestock BMPs ... 77
Support Enhancements to the Cache Creek Settling Basin ... 77
Develop and Enforce New Development Guidelines ... 77
Undertake Research and Special Studies ... 77
Conduct Pilot Sediment Study in the Northern Yolo Bypass ... 77
Conduct Colusa Basin Drain Diversions Study ... 77
Conduct Sediment Methylation Study ... 78
Conduct Wetland Management Study ... 78
Investigate Vector Control Pesticides ... 78
Conduct Desalinization Research ... 78
Conduct Bacteria Special Study ... 78
Conduct Salinity Source Control Study ... 79

Conduct Tertiary Treatment Benefits Study 79
Investigate Feasibility of Improving Migratory Fish Passage 79
Develop a Water Quality Model for the Bypass 79
Monitor Water Quality 80
Monitor Water Quality in the UC Davis Campus Arboretum Waterway 80
Monitor Local Methylmercury Concentrations 80
Monitor Pesticide Concentrations in Bypass Inputs 80
Monitor Receiving Waters for NPDES Permittees 80
Monitor Under the Agricultural Discharge Permit Waiver Program 81
Monitor Bypass Hydrology and Geomorphology 81
Monitor to Estimate Mercury Loads 81
Conduct Fish Tissue Sampling 81
Develop a Sustainable Baseline Water Quality Monitoring Program 81
Conduct Site-specific Objective or Beneficial Use Studies 82
Aluminum 83
Boron and Salinity 84
Participate in Future Stakeholder Activities 84
Conduct Stakeholder Meetings 85
Develop a Master Yolo Bypass Water Quality Database 85
Track and Participate in the Development of Relevant Environmental Management Plans and Policies 85
Pursue Water Quality Trading 87
Address New POCs 87
References 88

Appendix 1. Stakeholder Meeting Minutes
Appendix 2. Draft Hydrologic Timeline for the Yolo Bypass
Appendix 3. Pictorial Representation of Maximum Flows in the Yolo Bypass
Appendix 4. Monitoring Site Photographs
Appendix 5. Quality Assurance Project Plan
Appendix 6. Project Monitoring Results and Summary Statistics
Appendix 7. LWA Tech Memo of Potential Control Measures for POCs

List of Tables | Page

Table 1. Potentially applicable water quality criteria used to evaluate monitoring data. 9

Table 2. 2002 303(d) list of impaired waters associated with the Yolo Bypass and status of TMDLs. 11

Table 3. Basic hydrology of the Yolo Bypass. 13

Table 4. Land use summary of watersheds contributing to the Yolo Bypass. 19

Table 5. Description of Yolo Bypass Monitoring Sites 21

Table 6. Summary of constituents and parameters monitored by the project. Sample sites and number of events are shown. 25

Table 7. Sampling schedule for analytes by site and event. 26

Table 8. Estimated flow rates (in cubic feet per second) at sampling sites during sampling. 28

Table 9. Average water column concentrations for POCs grouped by site characterization and season. 30

Table 10. Prioritization of POCs for the Yolo Bypass Water Quality Management Plan. 47

Table 11. Summary table of control measures and the POCs that each addresses, as described in this section. 49

Table 12. Potential Mercury Source Control Strategies. 55

Table 13. Public outreach activities to address POCs. 61

Table 14. Summary of recommended options for addressing the POCs. 75

List of Figures | Page

Figure 1. Location of the Yolo Bypass along with local urban areas and water bodies. 2

Figure 2. Basic elements of the planning process. The three interconnected elements form the framework for this document and a framework for adaptive management. 3

Figure 3. General land use in the upstream watersheds of the Yolo Bypass, not including the Feather River or upper Sacramento River watersheds. 18

Figure 4. Seasonal uses of the Yolo Bypass (Sommer et al., 2001). The flow rates presented in the graph at top represent normal (solid line) and extreme (upper and lower dashed lines) years. 20

Figure 5. Map of Yolo Bypass water quality monitoring stations for a) northern and b) southern portion. 23

Figure 6. TSS versus total coliform concentrations in Willow Slough Bypass samples. There is no criterion for total coliform. 32

Figure 7. Total boron concentrations and flow rate measured in Cache Creek. 33

Figure 8. TSS versus total aluminum concentrations for combined Tule Canal at I-80 and Toe Drain sites' data. The criterion of 87 ug/L is indistinguishable at the bottom of the scale of this figure. 34

Figure 9. Box plots of a) total mercury and b) methylmercury concentrations at all sample sites. 36

Figure 10. Average TSS versus average a) total mercury (THg) and b) methylmercury (MeHg) concentrations for all sites monitored for mercury. The linear regressions are not valid, but are used to indicate relative ratios. 36

Figure 11. Total mercury (THg) versus methylmercury (MeHg) content in sediments collected at each sample site. 37

Figure 12. Concentrations of a) total mercury and b) methylmercury in Cache Creek plotted along with flow rate. The total mercury criterion of 50 ug/L is above the scale on Figure a; the methylmercury criterion of 0.06 ug/L is indistinguishable at the bottom of the scale in Figure b. 38

Figure 13. TSS versus total mercury concentrations in Cache Creek. The criterion of 51 ug/L is above the scale of this figure. 40

Figure 14. TSS versus a) total mercury and b) methylmercury concentrations in Tule Canal and Toe Drain sample results. Methylmercury is not correlated with TSS. 40

Figure 15. Breakdown of sources of chloride to municipal treatment plants in the Santa Clarita Valley area. 45

List of Acronyms

BMP – Best Management Practice

CCRMP – Cache Creek Resources Management Plan

cfs – cubic feet per second

CTR – California Toxics Rule

CVRWQCB – Central Valley Regional Water Quality Control Board

DOC – Dissolved Organic Carbon

DWR – California Department of Water Resources

EC – electro-conductivity

IRWMP – Integrated Water Resources Management Plan

MGD – million gallons per day

NAWQA – National Water Quality Assessment Program

NPDES – National Pollutant Discharge Elimination System

OC – organochlorine

OP – organophosphate

POC – Pollutant of Concern

RO – Reverse Osmosis

SSO – Site-specific Objective

SWPPP – Storm Water Pollution Prevention Plans

TDS – Total Dissolved Solids

TMDL – Total Maximum Daily Load

TOC – Total Organic Carbon

TSS – Total Suspended Solids

UAA – Use Attainability Analysis

UC Davis – University of California, Davis

USBLM – United States Bureau of Land Management

USEPA – United States Environmental Protection Agency

USGS – United States Geological Survey

WER – Water Effects Ratio

YBWA – Yolo Bypass Wildlife Area

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The CalFed project liaison was Casey Walsh Cady of the California Department of Food and Agriculture. Stefan Lorenzato of the California Department of Water Resources served as CalFed Contract Manager. William Ray of the State Water Resources Control Board was the CalFed QA Officer.

The City of Woodland Project Manager was Gary Wegener. Principal project contacts for the City of the Woodland were Mitch Dion and Christine Engel. Keith Smith was the principal contact for the City of Davis.

The City of Woodland contracted with Larry Walker Associates to perform many of the tasks funded by the grant. Contractor project managers were Armand Ruby and Tess Dunham of LWA. Chris Erichsen was responsible for monitoring program coordination, and contributed in many ways throughout the project. Claus Suverkropp served as Contractor QA officer. Stephen McCord was the principal author of the plan. Chuck Dudley served as subconsultant to LWA for agricultural activities and processes.

The Yolo Basin Foundation, led by Robin Kulakow, provided logistical support for the Stakeholder Advisory Group meetings. Facilitation of the stakeholder meetings was provided by Armand Ruby, initially with LWA and later with Armand Ruby Consulting.

Reviewers of the draft plan included Marianne Kirkland of the California Department of Water Resources, Petra Marchand of the Yolo County Planning Department, Betty Yee of the Central Valley Regional Water Quality Control Board, Christine Engle of the City of Woodland Department of Public Works, and Armand Ruby of Armand Ruby Consulting.

Collection of monitoring program samples was performed by volunteers led by professional staff from LWA, who also volunteered their time for the sample collection effort. Sample collectors included: Chris Erichsen, Armand Ruby, Stephen McCord, Yazmin O'Quinn, Andrea Erichsen, Nathan Ruby, Emily Ruby, Cheryl Ruby, Jeff Magee, Elizabeth Vignola, Kyle Sills, Kristine Corneillie, Todd Corneillie, Chuck Dudley, Dale Morris, and Steve Fanner. Special acknowledgement goes to Chris Erichsen, who tirelessly and conscientiously performed the many tasks required to coordinate and implement this very complex monitoring program.

STAKEHOLDERS ADVISORY GROUP PARTICIPANTS

The Stakeholders Advisory Group (SAG) was formed early in the project, and included representatives from local, regional, state and federal agencies and organizations. The group met five times and provided invaluable input into every key aspect of the project. This list identifies participants in SAG meetings.

- Armand Ruby, Larry Walker Associates (LWA) and Armand Ruby Consulting
- Brian Heiland, California Department of Water Resources (DWR)
- Betty Yee, Central Valley Regional Water Quality Control Board
- Casey Walsh Cady, Calif. Department of Food & Agriculture
- Chris Erichsen, LWA
- Christine Engel, City of Woodland
- Chuck Dudley, Dudley Ag
- Dave Feliz, California Department of Fish & Game, and Yolo Wildlife Area
- David Phillips, University of California, Davis
- Dawn Lindstrom, Putah Creek Council
- Denise Sagara, Yolo County Farm Bureau
- Doug Baxter, City of Woodland
- Jan Lowrey, Cache Creek Conservancy
- Janna Harren, California Department of Fish & Game
- Jim Beatty, City of Davis
- John Curry, Dixon Resource Conservation District
- John McNerny, City of Davis
- Kathryn Kuivila, US Geological Service
- Keith Smith, City of Davis
- Marianne Kirkland, DWR Division of Environmental Services
- Mike Hall, Conaway Ranch
- Mike Hardesty, Reclamation District 2068
- Paul Robins, Yolo County Resource Conservation District
- Petrea Marchand, Yolo County Planning Department
- Rich Marovich, Lower Putah Creek Coordinating Committee
- Rick Landon, Yolo County Agricultural Commissioner
- Robin Kulakow, Yolo Basin Foundation (YBF)
- Rollie Baxter, City of Woodland
- Stephen McCord, LWA
- Ted Sommer, DWR
- Tess Dunham, LWA

INTRODUCTION

Historically, the Yolo Bypass area was a natural wetland with local groundwater seeping to the surface and draining southward to the Delta. Major storm events in the Sacramento Valley would flood the entire low-lying area surrounding the Sacramento River, creating what was referred to as an inland sea (Kelley, 1989). To gain control over the devastating floods, the Yolo Bypass was constructed in the 1930s as the centerpiece of the Sacramento River Flood Control Project, authorized initially by Congress in the Flood Control Act of 1917.

The northern beginning of the Bypass is the Fremont Weir. Water spills over the weir from the Sacramento River when flows in the river exceed approximately 70,000 cfs. The weir is located near the River's confluence with the Sutter Bypass, which at this point includes water from Sacramento Slough and Feather River. The smaller Sacramento Weir allows additional flood flows (i.e., only during the highest flows) to drain into the Bypass from the Sacramento and American Rivers near the confluence of those two rivers. Additional water is contributed from the Knights Landing Ridge Cut, Cache Creek, Willow Slough, and Putah Creek.

The Bypass is paralleled by the lower Sacramento River on its east side (separated by the City of West Sacramento) and is part of the counties of Yolo and Solano on the west side (Figure 1). In more than half of all water years[1], the Bypass gets inundated. Water depths during flood discharges average 5-10 ft. Outside of flood discharge periods (i.e., for flows less than approximately 3,500 cubic feet per second (cfs)), water in the Bypass is conveyed entirely in the perennial eastern side channel referred to as Tule Canal north of I-80 and the Toe Drain south of I-80. The Toe Drain parallels the Sacramento River Deep Water Ship Channel.

Because of the control structures and frequent water management decisions, the Bypass watershed is a complex and ever-changing drainage area. During the dry season, the Bypass' main water sources are municipal wastewater and the west side tributaries of Cache and Putah Creeks. Diversions of irrigation return flows from the Colusa Basin Drain and the lower Sacramento River can also be significant. During the wet season, local and west side runoff is dwarfed by flood flows from the Sacramento, Feather, and American Rivers.

[1] A water year, based on typical wet-dry season periods, is from October 1 to September 30.

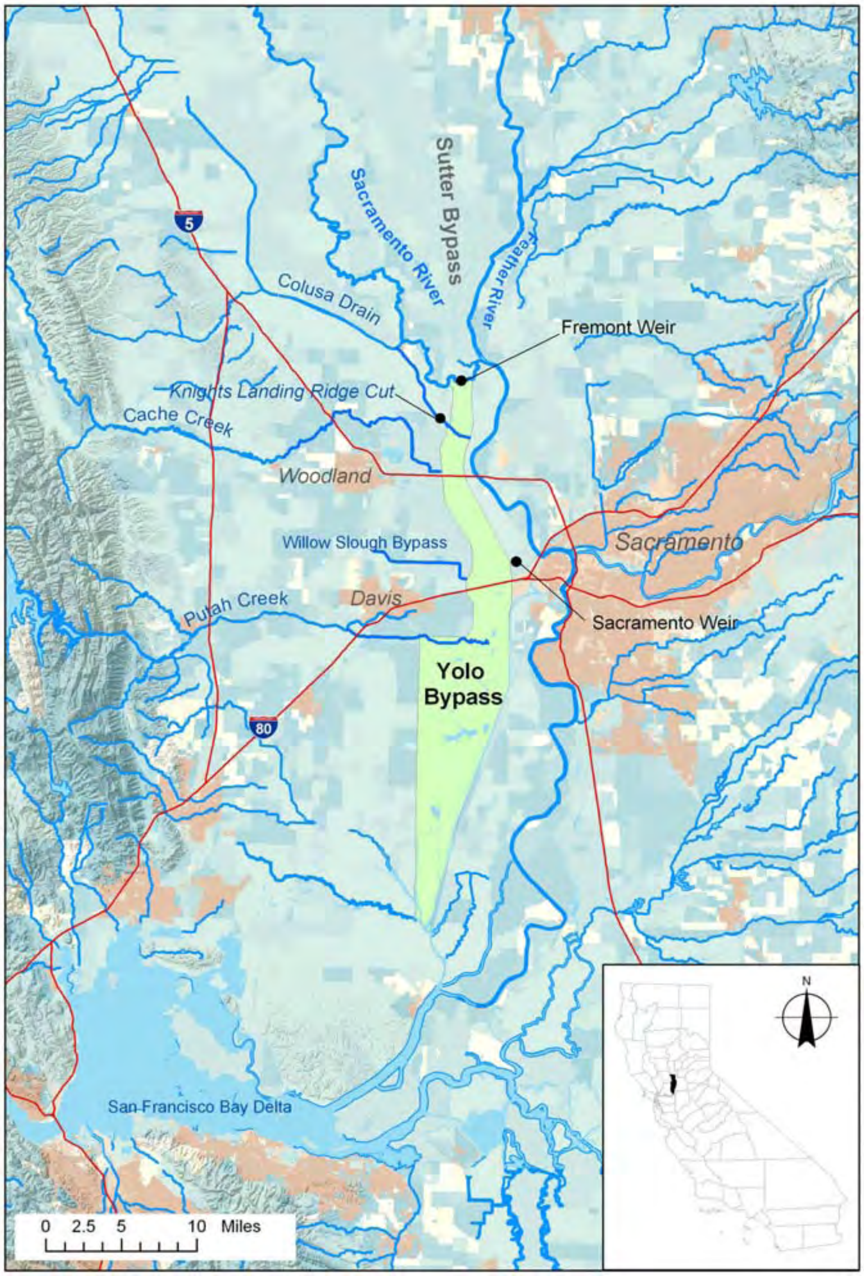

Figure 1. Location of the Yolo Bypass along with local urban areas and water bodies.

Goals and Objectives of the Project

The objective of this project has been to develop a comprehensive water quality management plan for the Bypass. The development of this plan has followed the fundamental problem-solving approach depicted in Figure 2. The three inter-related elements – problem definition/evaluation, information gathering, and recommended actions – guided the development of this plan. Future activities recommended to implement this plan also follow this adaptive management framework.

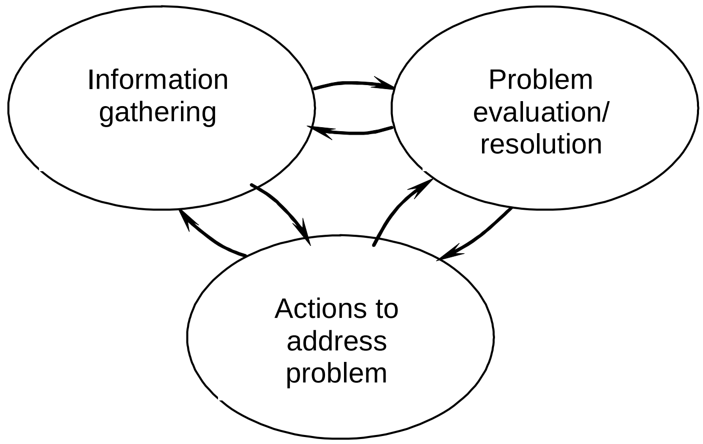

Figure 2. Basic elements of the planning process. The three interconnected elements form the framework for this document and a framework for adaptive management.

The approach was framed in terms of the basic elements presented in Figure 2 and focused on the pollutants of concern (POCs).

Information gathering consisted of the following activities:

- Form an advisory group of Yolo Bypass stakeholders to participate in a collaborative process of developing this plan;
- Compile and evaluate existing water quality, flow, and land use information; and
- Identify the current water quality issues and POCs.

Problem evaluation/resolution consisted of the following activities:

- Conduct a surface water quality assessment and monitoring program to quantify the POCs and their apparent sources within the Bypass; and
- Assess whether the measured levels of POCs are causing impairment of beneficial uses in the Bypass.

Actions to address problems consisted of the following activities:

- Identify and evaluate alternative control measures for reducing POC concentrations and loads;
- For those POCs for which effective controls appear technically or economically infeasible, investigate applicability of current water quality objectives and, if appropriate, develop site-specific objectives, pollutant trading, or other alternative approaches;
- Provide public education and obtain public input regarding potential methods for improving water quality in the Bypass and reducing pollutant loads to the Delta; and

- Develop a Water Quality Management Plan report containing recommended implementation strategies to reduce POCs that are degrading beneficial uses in the Bypass.

The POCs identified by stakeholders and assessed in the monitoring program are listed later in this section. Potential controls for high and medium priority POCs are identified in the next section. The comprehensive water quality management plan is presented at the end of this report.

Stakeholder Process

Stakeholder input and review was integral throughout the study and development of this plan. A Stakeholder Advisory Group was formed early in the project. This advisory group included representatives from public agencies, agriculture, and environmental advocates:

- Local municipalities – staff members from the cities of Davis and Woodland, University of California Davis (UC Davis) campus, and counties of Yolo and Solano, particularly those responsible for municipal wastewater treatment facilities and stormwater management programs;
- Agricultural interests – Yolo County Farm Bureau, Dixon Resource Conservation District, and Yolo County Agricultural Commissioner's office;
- Local environmental and resource conservation groups – Yolo Basin Foundation, Ducks Unlimited, Cache Creek Conservancy, Putah Creek Council;
- State agencies – Central Valley Regional Water Quality Control Board (CVRWQCB or Regional Board), California Department of Water Resources (DWR), State Water Resources Control Board (State Board), California Department of Health Services, California Department of Fish and Game; and
- Federal agencies – US Fish and Wildlife Service, US Environmental Protection Agency (USEPA) Region 9.

The Yolo Basin Foundation initiated the Yolo Bypass Working Group in 1998 under a CalFed Ecosystem Restoration Grant. This ad hoc stakeholder group has been very successful and continues to meet approximately every two months. Over 30 people representing a wide range of stakeholders with an interest in the Yolo Bypass regularly attend these meetings. Stakeholders that participated in this study informally represent a subset of the Yolo Bypass Working Group.

Stakeholder meetings covered the following topics:

1. 25 July 2003 – reviewed the project goals, objectives and approach; discussed water quality objectives applicable to the Bypass and potential list of POCs; discussed local hydrology and water management; identified proposed water quality monitoring sites, analytes and sampling frequency.
2. 15 October 2003 – discussed specific local hydrology and water management issues; discussed available monitoring data; agreed on list of POCs, monitoring sites, and sampling frequency;
3. 22 June 2004 – reviewed interim monitoring data; presentations by stakeholders: National Pollutant Discharge Elimination System (NPDES) permit compliance issues, wetland management and restoration issues, agricultural users' issues, Department of Water Resources' (DWR's) concerns and activities, and Regional Board concerns and priorities.

4. 3 December 2004 – reviewed project schedule; reviewed preliminary monitoring results; prioritized POCs; discussed potential control measures; discussed report outline.
5. 7 February 2005 – reviewed project schedule and remaining budget; identified feasible control measures by POC and discussed need to investigate site-specific objectives.

Minutes for these stakeholder meetings are included in Appendix 1.

Identification of POCs

The stakeholder group developed a list of POCs based on current water quality concerns and interests for monitoring. The list of POCs and the rationale for their inclusion are as follows[2]:

- **Bacteria.** Total coliform, fecal coliform and *E. coli* are used by regulatory agencies as indicators of human pathogens. The presence of these constituents may also indicate contamination from domestic animals and wildlife. The presence of high levels of coliform and *E. coli* may indicate the presence of pathogens of human health concern in waters used for contact recreation. The presence of high levels of coliform and *E. coli* in irrigation water may also indicate the presences of pathogens that cause human health concerns in some food crops.
- **Boron.** Boron is an element commonly found in saline groundwater sources. It has properties that are somewhat like metals. The major source locally is leaching from soil and extraction in groundwater. High concentrations of boron can stress rice and other irrigated crops.
- **Metals.** Aluminum, mercury, and selenium have been detected in the Bypass at levels in excess of water quality standards. Copper, chromium(III), and lead have also been detected. Some metals, such as aluminum and selenium, tend to be from natural sources. Mercury was mined extensively in the Cache and Putah Creek watersheds prior to any environmental regulations. Wetlands tend to enhance the methylation process that drives bioaccumulation. Other metals tend to come from urban runoff and municipal wastewater discharges. Most metals are a concern for toxicity to aquatic organisms. Mercury and selenium are potent neurotoxins of concern to humans and wildlife.
- **Nitrate.** Nitrate is a concern for human health and eutrophication. It is often present at elevated levels in municipal wastewater discharges, agricultural irrigation tailwater, and urban runoff.
- **Organic Carbon.** Organic carbon in water increases productivity of aquatic ecosystems but is detrimental to drinking water supplies. The presence of high levels of organic carbon in drinking water requires drinking water providers to increase the chlorination process in order for drinking water to meet appropriate standards when delivered to consumers. However, the chlorination process creates harmful disinfection by-products known as trihalomethanes. Trihalomethanes are considered to be carcinogenic.
- **Pesticides.** Carbamate, organochlorine, and organophosphate based pesticides have been detected in Bypass water by existing water monitoring programs. The presence of these pesticides above threshold concentrations can cause negative impacts on aquatic life within the Bypass. Common sources of such pesticides, such as agricultural and urban runoff, exist in the watershed.

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[2] This list was reorganized slightly from the original list to facilitate grouping the analyses presented subsequently.

- **Salinity.** High salts content in water potentially impacts productivity of agricultural crops and may create problems for municipal uses. Local groundwater aquifers, the principal water supply source for the Cities of Davis and Woodland and UC Davis campus, are relatively high in salts content. Urban water uses, particularly the use of water softeners, increase salts content in wastewater discharges. Irrigation practices that enhance evaporation and leaching also increase salt content of irrigation return flows.
- **Total Suspended Solids (TSS).** TSS is often used as a standard indicator of erosion and sediment transport. Many POCs are strongly associated with particulates measured as TSS.

In addition to standard field measurements of temperature and pH, the following were also determined to be of interest for monitoring:

- **Chronic Toxicity.** Testing for chronic toxicity was conducted for water column and sediment samples to directly measure the presence of aquatic toxicity. The testing involves exposing selected organisms to receiving water samples for a period of 96 hours to 7 days, depending on the species. The species most commonly selected for freshwater toxicity tests include a cladoceran (*Ceriodaphnia dubia*), fathead minnows, and algae (*Selenastrum capricornutum*). Toxicity is defined as a statistically significant difference in effects such as growth rate.
- **Sediment.** Sediment samples were also collected and analyzed for metals, pesticides, and TOC.
- **Color.** Color is a potential indicator of effects of agricultural runoff.
- **Hardness.** Hardness affects toxicity for metals, with lower hardness increasing metals toxicity.

Support for CalFed Watershed Program and Coordination with Other Programs

This plan is related in purpose with several other efforts within the Yolo Bypass watershed. The most relevant efforts, described in the final section of this report, include:

- California Drinking Water Policy,
- Yolo County Integrated Water Resources Management Plan,
- Cache Creek Resources Management Plan,
- Willow Slough Watershed Resources Management Plan, and
- Yolo Bypass Wildlife Area Management Plan.

Regulatory Framework

The regulatory framework described in this section identifies the major regulations with which any actions would have to comply.

Basin Plan Beneficial Uses

Beneficial uses of water in the Yolo Bypass are legally designated in the Basin Plan (CVRWQCB, 1998). Beneficial use designations determine the applicable water quality objectives. In addition to the beneficial uses for the Yolo Bypass, there are additional and different beneficial uses for the water bodies in and near the Bypass such as Cache Creek, Putah Creek and the Delta. Consequently these additional beneficial uses should also be considered. Between these water bodies, almost every beneficial use designation applies. The various beneficial uses include:

- Agricultural Supply (AGR) – Uses of water for farming, horticulture, or ranching including, but not limited to, irrigation (including leaching of salts), stock watering, or support of vegetation for range grazing.
- Water Contact Recreation (REC-1) – Uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, white water activities, fishing, or use of natural hot springs.
- Non-contact Water Recreation (REC-2) – Uses of water for recreational activities involving proximity to water, but where there is generally no body contact with water, nor any likelihood of ingestion of water. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.
- Warm Freshwater Habitat (WARM) – Uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.
- Cold Freshwater Habitat (COLD) – Uses of water that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.
- Spawning, Reproduction, and/or Early Development (SPWN) – Uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish.
- Wildlife Habitat (WILD) – Uses of water that support terrestrial or wetland ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats or wetlands, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.

An additional beneficial use, Municipal and Domestic Supply (MUN) does not apply to the Bypass but does apply to Cache Creek and Putah Creek upstream and to the Delta downstream.

Most Restrictive Potentially Applicable Water Quality Criteria

Water quality objectives are defined by the California Water Code[3] as "the limits or levels of water quality constituents or characteristics which are established for the reasonable protection of beneficial uses of water or the prevention of nuisance within a specific area." Such objectives are to be adopted into the Basin Plan to protect reasonable beneficial uses after considering a number of factors. The Basin Plan currently contains some numeric water quality objectives for the POCs addressed in this report. However, many of the applicable objectives are in the narrative format. When objectives are narrative, the Regional Board has established a practice of interpreting the narrative objectives with available water quality criteria from a variety of sources. The actual criteria used by the Regional Board when interpreting narrative objectives may vary on a case-by-case basis. As a result, it is difficult to accurately predict what criteria may be applicable to the POCs. In order to compare the monitoring results with some baseline water quality

[3] See CA Water Code §13050.

indicator, this report utilizes the most potentially restrictive criteria available to determine if a POC is a concern with regard to maintaining water quality standards. The criteria used herein are for comparison and baseline purposes only and may or may not be used by the Regional Board in a regulatory permitting context. The most restrictive potentially applicable criteria for the various POCs are provided here.

Bacteria

The beneficial use most in need of protection from bacteria is Water Contact Recreation (REC-1). The Basin Plan specifies that the fecal coliform geometric mean of at least five samples for any 30-day period shall not exceed 200 Most Probable Number per 100 mL (MPN/100mL), nor shall more than ten percent of the total number of samples taken during any 30-day period exceed 400/100 mL. A proposed Basin Plan amendment requires that “In waters designated for contact recreation (REC-1), the E. coli concentration, based on a minimum of not less than five samples equally spaced over a 30-day period, shall not exceed a geometric mean of 126 MPN/100 mL and shall not exceed 235 MPN /100 mL in any single sample.

Boron

The United Nations Recommended Agricultural Water Quality Goals for total boron is 700 ug/L for the most sensitive crops (Ayers and Westcot, 1985). Agricultural Water Quality Criteria contained in the United Nations are not adopted water quality objectives contained in the Basin Plan. However, the Regional Board has used the recommended goals contained in the United Nations Report to interpretative narrative objectives contained in the Basin Plan.

Metals

Aluminum

The USEPA National Recommended Ambient Water Quality Chronic Aquatic Life Criterion for total aluminum concentration is 87 ug/L and the recommended acute criterion is 750 ug/L. There is no criterion for dissolved aluminum. The recommended chronic criteria of 87 ug/l is qualified and is considered to apply mostly to waters that are low in pH (6.5-6.6) and low in hardness (< 10 mg/l). The average pH and hardness for the in-Bypass monitoring sites was 8.0 and 223 mg/L, respectively.

Chromium

Based on an average hardness in the Bypass of 220 mg/L, the California Toxics Rule (CTR) criterion for dissolved chromium (III) in freshwater is 340 ug/L as a continuous (four-day average) concentration. The CTR reference value for total chromium (III) is 395 ug/L.

Copper

Based on an average hardness in the Bypass of 220 mg/L, the CTR criterion for dissolved copper in freshwater is 17.6 ug/L as a continuous (four-day average) concentration. The CTR reference value for total copper is 18.3 ug/L.

Lead

Based on an average hardness in the Bypass of 220 mg/L, the CTR criterion for dissolved lead in freshwater is 5.9 ug/L as a continuous (four-day average) concentration. The CTR reference value for total lead is 8.68 ug/L.

Mercury

The CTR has a total mercury criterion of 51 ng/L as a monthly average, intended to be protective for consumption of organisms. There is no CTR criterion for methylmercury, although the Cache Creek mercury Total Maximum Daily Load (TMDL) has proposed a water quality objective of 0.06 ng/L.

Selenium

The CTR criterion for total selenium is 5.0 ug/L as a continuous (four-day average) concentration in freshwater.

Nitrate

While there is no nitrate objective applicable to the Bypass, the USEPA Ambient water quality criterion is 10 mg-N/L[4]. Local site conditions, particularly the availability of other nutrients for algal growth, play an important role in determining actual effects of elevated nitrate concentrations.

Organic Carbon

There are no recognized standards for TOC or DOC in surface waters. For drinking water, lower organic carbon concentrations are better, regardless of the magnitude.

Pesticides

The lowest potentially applicable criteria for detected pesticides are shown in Table 1. These values were obtained from CVRWQCB (2003). Quite commonly, applicable criteria for pesticides are below the analytical detection limit. The evaluation in this report of water quality issues related to pesticides focuses on detected compounds.

Table 1. Potentially applicable water quality criteria used to evaluate monitoring data.

Pesticide	Criteria (ug/L)	Source
Diuron	10	Drinking Water Health Advisory or Suggested No Adverse Response Level for toxicity other than cancer risk
Methomyl	0.52	USEPA National Recommended Ambient Water Quality Criterion
4,4'-DDE	0.00059	California Toxics Rule for consumption of aquatic organisms
Diazinon	0.1	USEPA draft recommended criteria
Chlorpyrifos	0.009	Derived by the California Department of Fish and Game; not a national recommended criterion.

Salinity

The United Nations agricultural goals for salt-sensitive crops in arid areas include, but are not limited to, 106 mg/L chloride, 700 umhos/cm specific conductance, and 450 mg/L total dissolved solids. The Regional Board has utilized these goals as six-month or annual averages in recent NPDES permits. The State Board has recently determined that the UN criteria may need to be adjusted to site-specific conditions, including climate (SWRCB Order No. WQO-2004-0010).

[4] The units are given as mg *of nitrogen (N)* per liter.

List of Impaired Waters and TMDL Status

Under Section 303(d) of the 1972 Clean Water Act, states, territories and authorized tribes are required to develop a list of water quality limited segments. These waters on the list do not meet water quality standards, even after point sources of pollution have installed the minimum required levels of pollution control technology. The law requires that the state establish priority rankings for water on the lists and establish pollutant loads for the various sources called Total Maximum Daily Loads (TMDLs). TMDL implementation plans are legally enforceable once adopted in the Basin Plan.

The 2002 state-wide listing of impaired waters, referred to as the "303(d) list", was approved by USEPA on July 25, 2003. Direct tributaries upstream and the Delta downstream are listed as impaired as indicated in Table 2. The Yolo Bypass is not listed as impaired. However, TMDLs are in various stages of development and implementation for water bodies both upstream and downstream of the Yolo Bypass.

NPDES Permits

The National Pollutant Discharge Elimination System (NPDES) permit program was established under Section 402 of the CWA, which prohibits the unauthorized discharge of pollutants from a point source (pipe, ditch, well, etc.) to waters of the U.S., including municipal, commercial, and industrial wastewater discharges and discharges from large animal feeding operations. Permittees must verify compliance with permit requirements by monitoring their effluent, maintaining records, and filing periodic reports. Different types of discharges to waters of the State are permitted through various NPDES permit programs. The following permit programs are relevant within the local Yolo Bypass watershed:

- Construction storm water runoff – Construction sites disturbing one acre or more of land are required to comply with a statewide general permit. The permit prohibits the discharge or any pollutants from construction sites and requires Storm Water Pollution Protection Plans (SWPPPs) for all permitted sites.
- Industrial storm water runoff – Industrial facilities meeting certain criteria for size and potential pollutants on site are required to comply with a statewide general permit. The permit prohibits the discharge or any pollutants from the property and requires SWPPPs for all permitted sites.
- Stormwater – Municipalities and non-traditional entities meeting certain population size, growth criteria, location, or pollution potential are required to comply with a permit for the discharge of storm water to waters of the State. Elements required for each entity's stormwater management program include: Public Education and Outreach, Public Involvement and Participation, Illicit Discharges, Construction Activities, New Development and Redevelopment, and Municipal Operations.
- Wastewater – Municipal, commercial, and industrial wastewater discharges, and discharges from large animal feeding operations are regulated by the NPDES permit program. Individual permits are granted with conditions and limits on the effluent water quality. Discharges of municipal and industrial wastewater to land are regulated through state Waste Discharge Requirements.

Specific permittees regulated by these permit programs are described next in the Environmental Setting section.

Table 2. 2002 303(d) list of impaired waters associated with the Yolo Bypass and status of TMDLs.

Water Body	Pollutant / Stressor	Priority	Potential Source(s)	TMDL Status
Sacramento River (Red Bluff to Knights Landing)	Unknown toxicity	Low	Unknown	No activity
Feather River (Lake Oroville Dam to Confluence with Sacramento River)	Diazinon	High	Agriculture, Urban Runoff/Storm Sewers	Adopted
	Group A Pesticides	Low	Agriculture	No activity
	Mercury	Medium	Resource extraction	No activity
	Unknown toxicity	Low	Unknown	No activity
Sutter Bypass	Diazinon	Medium	Agriculture	Adopted
Colusa Basin Drain	Azinphos-methyl	Medium	Agriculture	No activity
	Carbofuran/Furadan	Low	Agriculture	No activity
	Diazinon	Medium	Agriculture	Adopted
	Group A Pesticides	Low	Agriculture	No activity
	Malathion	Low	Agriculture	No activity
	Methyl Parathion	Low	Agriculture	No activity
	Molinate/Odram	Low	Agriculture – irrigation tailwater	No activity
	Unknown Toxicity	Low	Agriculture	No activity
Clear Lake	Mercury	High	Resource extraction	Adopted
	Nutrients	Medium	Unknown	Draft Technical Report completed
Sulphur Creek	Mercury	Medium	Resource extraction	2nd draft staff completed
Harley Gulch	Mercury	Medium	Resource extraction	2nd draft staff completed
Cache Creek	Mercury	Medium	Resource extraction	2nd draft staff completed
	Unknown toxicity	Low	Unknown	No activity
Lake Berryessa	Mercury	Low	Resource extraction	No activity
Lower Putah Creek	Mercury	Low	Resource extraction	No activity
Delta (eastern portion)	Mercury	Medium	Resource extraction	Draft staff report in progress
	Unknown toxicity	Low	Unknown	No activity
	Chlorpyrifos and Diazinon	High	Agriculture, Urban Runoff/Storm Sewers	Draft staff report in progress
	DDT	Low	Agriculture	No activity
	Group A pesticides	Low	Agriculture	No activity

Waivers from Waste Discharge Requirements

Irrigation return flows and stormwater runoff from agricultural fields is not regulated under the federal NPDES permit program like the other types of discharges described above. Instead, agricultural sources of nonpoint source pollution are subject to state water quality requirements stemming from California's Porter-

Cologne Water Quality Control Act. Under Porter-Cologne[5], all potential discharges of waste into waters of the state are required to file a report of waste discharge and obtain waste discharge requirement, unless waived by the State or Regional Board. The CVRWQCB adopted a *Conditional Waiver for Irrigated Agriculture* in July of 2003. Under the *Conditional Waiver*, farmers with irrigation return flows and stormwater runoff from irrigated agricultural lands are not required to submit a report of waste discharge and obtain waste discharge requirements. However, in lieu of such requirements, growers are required to comply with the conditions of the waiver, which includes extensive monitoring requirements and the establishment of water quality management plans if required by the Regional Board. The *Conditional Waiver* also encourages growers to utilize management practices for the protection of water quality in their agricultural operations.

404 Corps of Engineer Permits

In addition to the NPDES permit provisions described above, section 404 of the federal CWA requires individuals and public agencies to obtain a permit before discharging any dredge or fill into a water of the United States. Such permits are administered by the Secretary of the Army through the Chief Engineer at the Army Corps of Engineers. Since the Yolo Bypass is considered a water of the U.S., some of the identified control actions may require that a section 404 permit be obtained before being implemented.

A water quality certification is required from the Regional Board if a 404 permit is needed. In cases where the Army Corps of Engineers does not have jurisdiction (e.g., isolated wetlands), the Regional Board can still issue a water quality certification.

Streambed Alteration Agreements (California Fish and Game Code 1600 et seq.)

Besides needing to obtain a section 404 permit, some of the identified control actions may require that a streambed alteration agreement be obtained from the California Department of Fish and Game. Streambed alteration agreements are required if a project may in any way alter a streambed or obstruct or divert the flow of a natural waterway.

[5] See CA Water Code §13000 et seq.

ENVIRONMENTAL SETTING

This section describes the environmental setting driving the current water quality conditions in the Bypass.

Hydrology and Water Resources Management

Hydrology of the Yolo Bypass is affected by both local and distant conditions related to hydraulic control structures, water management decisions, and weather patterns. Hydrology and water management within the Bypass is summarized by season and Bypass segment in Table 3. A more detailed description of the Bypass hydrology on a monthly time scale is provided in draft form in Appendix 2[6].

Table 3. Basic hydrology of the Yolo Bypass.

Bypass Zone	Fall (September – December)	Wet Season (January – March)	Dry Season (April – August)
Upper (North of I-80)	Effluent from cities of Davis and Woodland; Knights Landing Ridge Cut water supplied to some irrigated fields; Conaway Ranch water supplied from Sacramento River	Effluent and pulses of stormwater runoff from cities of Davis, Woodland and the portion of West Sacramento north of I-80; increased flows from Knights Landing Ridge Cut, Cache Creek and Willow Slough;	Effluent from cities of Davis and Woodland utilized locally; Cache Creek flows and City of Woodland storm drains diverted to Conaway Ranch; irrigation tailwaters pumped back onto downstream fields
Transition (I-80 to Putah Creek)	Tidal prism extends up through this zone	Pulses of stormwater runoff from southern portion of City of Davis	Putah Creek water utilized in Yolo Basin Wildlife Area; tidal prism extends up through this zone; pumped irrigation water recycled or from Delta
Southern (South of Putah Creek)	Putah Creek "conservation releases" pulse plus UC Davis effluent	UCD effluent and pulses of stormwater runoff from UC Davis and; tidal prism restricted to this zone	Effluent from UC Davis; some water pumped out of Bypass; some land used for pasture
Bypass-wide	Rice fields drained; principal water use for flooding duck clubs, wildlife habitat and rice paddies (for straw decomposition)	Rainfall runoff from fields in and adjacent to Bypass; principal water use for flooding duck clubs, wildlife habitat and rice paddies (for straw decomposition); potential extreme flows from Sacramento River over Fremont Weir	Wildlife habitat reduced to brood ponds; farmland prepared, planted, irrigated, and harvested

[6] Description courtesy of Chuck Dudley.

As an alternative to the seasonal hydrologic calendar framing the discussion in Table 3, the annual hydrology for the Bypass can be described in terms of discharge:

- Dry (Irrigation) Season: Major sources of water include effluent from the municipal wastewater treatment plants (POTWs) of the Cities of Woodland and Davis and the UC Davis campus, imported Sacramento River water (for irrigation purposes), and water from the Toe Drain that is pumped onto agricultural fields for irrigation and to wildlife habitat. Low flows from Putah Creek, Willow Slough, Cache Creek, and Knight's Landing Ridge Cut also contribute. Agricultural tailwater is largely recycled
- Wet Season: Pulses of urban stormwater runoff combine with POTW effluent and higher flows in creeks to provide the primary sources of water within the Bypass. The available water created during the wet season is often used to flood public and private lands for duck clubs, wildlife habitat and the break-down of rice stubble remaining on rice fields after harvest.
- Flooded: Flood flows in the Bypass come from the Feather River and upper Sacramento River watersheds via the Fremont Weir at the northern end of the Bypass, from the American River via the Sacramento Weir along the east side of the Bypass, and from local creeks. These flood flows drastically alter what would be considered "average" conditions. It is not uncommon for flood flows to exceed 150,000 cfs in the Bypass during wet years, as compared to 20,000 cfs in Cache Creek, and 20 cfs combined POTW effluent. The basic surface water flow paths and maximum flow capacities in the Bypass are shown pictorially in Appendix 3.

Additional discussion of hydrology in the Bypass is provided by the Yolo Bypass Working Group et al. (2001).

Major Tributaries to the Yolo Bypass

The northern beginning of the Bypass is the Fremont Weir, located approximately 2 miles upstream of the town of Verona (see Figure 1 above and Figure 5 below). Water spills over the weir from the Sacramento River when flows in the river exceed approximately 70,000 cfs. Verona is at the confluence with the Feather River and Sutter Bypass[7]. Over ten times more water spilling over Fremont Weir may come from the Sutter Bypass than from the Sacramento River. By this mechanism, the Bypass relieves pressure on the main levee system along the river channel and helps keep flows within the channel's design capacity. The smaller Sacramento Weir, located approximately 3 miles upstream of the American River, allows additional flood flows (i.e., only during the highest flows) to drain into the Bypass from the Sacramento and American Rivers. The Fremont Weir is a fixed-crest overflow weir, thus flow into the Bypass is uncontrolled. On the other hand, the Sacramento Weir is gated, thereby controlling flow into the Bypass via the lateral Sacramento Bypass.

The Colusa Basin Drain (Drain) watershed comprises nearly 1,620 square miles in the Sacramento Valley, and includes portions of Glenn, Colusa, and Yolo counties. There are 32 ephemeral streams that convey storm runoff to the Drain. The Drain is an artificial channel designed to convey irrigation drainage to the Knights Landing outfall gates for discharge into the Sacramento River. When the water level in the river exceeds the water level in the Drain, Drain water discharges into the Knights Landing Ridge Cut directly into the Yolo Bypass. The Knights Landing Ridge Cut, which consists of two excavated channels with a

[7] The Feather River floods into the Sutter Bypass upstream of this point.

center island, has a discharge capacity of approximately 20,000 cfs. Water from the Drain is pumped into the Ridge Cut for irrigation at other times of the year, providing additional water into the upper Bypass during the summer-fall period.

Clear Lake and Indian Valley Reservoir each store approximately 300,000 acre-feet of water in the Cache Creek watershed. This water is delivered through Capay Valley but diverted at the Capay Dam for irrigation. During the dry season, Cache Creek downstream of Capay Dam is either dry or contains some groundwater ex-filtration and irrigation tailwater. Because of the different hydrologic conditions and water management, Cache Creek is often described in terms of an upper watershed upstream of Capay Dam and a lower watershed downstream of Capay Dam. Cache Creek discharges into the Bypass through the Cache Creek Settling Basin, an integral component of the Yolo Bypass flood control project. The basin directs water from Cache Creek into the Bypass through a low-flow channel passing on the west and south side of the basin area. When the low-flow culvert's discharge capacity is exceeded (approximately 400 cfs), the basin begins to fill. When the outlet weir height is reached, water spills over the weir into the Bypass. By reducing the sediment load from this highly erosive watershed, flood conveyance capacity is maintained in the Bypass. Nonetheless, a sediment fan is observable directly east of the basin, in the Bypass.

The Willow Slough watershed drains most of the central part of Yolo County between Cache Creek and Putah Creek. Because of natural levees that formed through deposition of sediment along the valley floor, local runoff flows *away* from the main Cache Creek and Putah Creek channels and enters a complex network of sloughs and small drainage channels that flow eastward and eventually consolidate into Willow Slough before discharging into the Yolo Bypass. Landowners have realigned and reconfigured many of the sloughs to accommodate agricultural activities. Runoff has undoubtedly been accelerated by grazing in the upper watershed and foothills areas and widespread land leveling and prebedding of fields in the valley floor area. East of State Highway 113, the northeast-trending natural channel of Willow Slough has been blocked off and replaced with a flood bypass channel, the Willow Slough Bypass, which flows directly east to the western edge of the Yolo Bypass. Water in the Slough during the dry season is entirely irrigation tailwater and field drainage and is used so efficiently that essentially none of this water reaches the Bypass.

The Monticello Dam on Putah Creek stores water in Lake Berryessa from a 576-square-mile drainage basin to the northwest of Solano County on the eastern slope of the Coast Range in Napa and Lake Counties[8]. Lake Berryessa has a storage capacity of 1,602,000 acre-feet. The water is released during the irrigation season and diverted into the 30-mile-long Putah South Canal. In addition to providing irrigation water, the canal conveys municipal and industrial water for Vacaville, Fairfield, Suisun, and Vallejo, as well as neighboring military installations. Although the majority of runoff from the Putah Creek watershed is diverted out of the Yolo Bypass watershed, 16-46 cfs is maintained through the Putah Diversion Dam at Lake Solano. The monthly non-diverted flow rate schedule was set in a settlement agreement[9].

The UC Davis Arboretum Waterway is a 100-acre constructed stormwater retention basin created in the 1960s along a portion of the historic channel of the North Fork of Putah Creek. All stormwater runoff from the central campus is routed into the Arboretum Waterway. Water collected in the channel largely infiltrates into the local aquifer. During a storm event, water from the Arboretum Waterway spills over a weir at the west end and large pumps send the water via pipeline into the South Fork of Putah Creek. The South Fork from the UC Davis campus to the Bypass is an engineered channel designed to convey flood flows.

[8] More information on the Solano Project can be found at http://www.usbr.gov/dataweb/html/solano.html.

[9] The settlement agreement can be viewed on-line at http://www.putahcreek.org/Settlement%20Agreement.htm.

Permitted Wastewater Dischargers

The permitted municipal wastewater treatment facilities in the watershed discharge as indicated here.

- City of Woodland – The secondary treatment facility discharges 6.8 million gallons per day (MGD) into Tule Canal.
- City of Davis – The secondary treatment facility with overland flow discharges approximately 6 MGD. Generally during the February-June period, effluent is discharged into a 400-acre wildlife habitat wetland and pumped from there into a drain on the west side of the Bypass at the mouth of Willow Slough Bypass. At other times effluent is discharged directly into Willow Slough Bypass.
- UC Davis campus – The advanced (tertiary) treatment facility with ultraviolet disinfection discharges 2.5 MGD into Putah Creek. The outfall is located by Old Davis Road south of the campus.

The City of Winters operates a grassland irrigation system that does not discharge to surface waters. Similarly, the City of Esparto operates a primary treatment facility with evaporation/percolation ponds that do not discharge to surface waters. Effluent from the City of West Sacramento is discharged into the lower Sacramento River. Facilities upstream of Clear Lake are not addressed. Industrial facilities discharge into municipal sewer service lines rather than directly into surface waters.

Permitted Stormwater Dischargers

Recently, larger urbanized areas within the Cache and Putah Creeks watersheds have been regulated under a statewide general permit for the discharge of water from municipal stormwater systems. These areas include:

- City of Woodland – Discharging into lower Cache Creek and the Bypass;
- City of West Sacramento – Discharging into the Yolo Bypass for most of the City;
- City of Davis – Discharging into Willow Slough Bypass and the Bypass. Some stormwater is diverted into the wildlife wetlands;
- County of Yolo, El Macero and Willowbank residential communities adjacent to South Davis – Discharging into the South Davis Drainage Ditch which is pumped into the Bypass; and
- UC Davis campus – Discharging into lower Putah Creek just upstream of the municipal wastewater treatment facility's outfall.

Agricultural Irrigation

Local farmers irrigate their land with both surface water and groundwater. Within the Bypass, water is pumped from the Sacramento River to some areas, while serendipitous flows in canals are also pumped onto fields within and adjacent to the Bypass. Irrigation tailwater and rainfall runoff flow back to the network of canals that lead into the Bypass and generally south-eastward towards the main in-Bypass drain, Tule Canal and the Toe Drain.

Water Withdrawals from the Bypass

The North Bay Aqueduct withdraws water out of Cache Slough at the southern end of the Bypass and delivers it through 27 miles of underground pipelines and two pumping plants to water users in Napa and Solano counties.

The communities west of the Bypass rely exclusively on local groundwater aquifers for potable water. Water supply for the City of West Sacramento comes from the Sacramento River.

Land Uses

Land uses are described for the Bypass' local watershed (i.e., not including the Sacramento and Feather Rivers watersheds) and for the Yolo Bypass proper.

Land Uses in the Yolo Bypass Watershed

Major land uses within the watersheds of the west-side tributaries are portrayed in Figure 3, and quantified in Table 4 which includes the Feather and upper Sacramento River watersheds. Agriculture, forest, and rangeland are the dominate land uses in the Bypass' watershed.

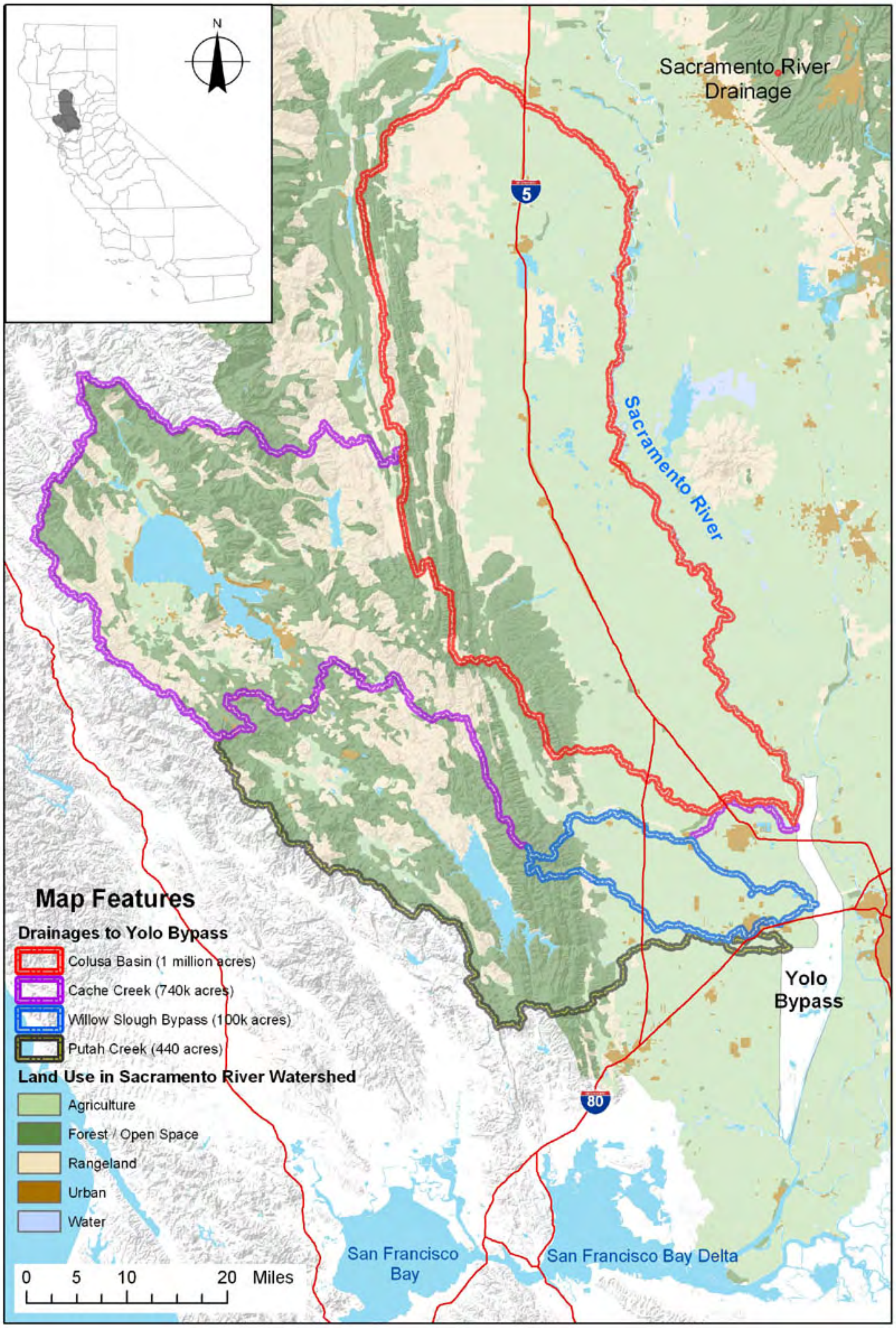


Figure 3. General land use in the upstream watersheds of the Yolo Bypass, not including the Feather River or upper Sacramento River watersheds.

Table 4. Land use summary of watersheds contributing to the Yolo Bypass.

Watershed	Land Use	Land Use Acres	Percent of Watershed
Willow Slough Bypass	***Total Acres***	***102,893***	
	Agriculture	85,843	83.4
	Forest	10,990	10.7
	Residential	4,451	4.3
	Rangeland	1,343	1.3
	Water	151	0.1
	Transitional Areas	114	0.1
Putah Creek	***Total Acres***	***435,777***	
	Forest	258,769	59.4
	Rangeland	106,003	24.3
	Agriculture	47,166	10.8
	Water	18,137	4.2
	Transitional Areas	3,027	0.7
	Residential	2,675	0.6
Cache Creek	***Total Acres***	***737,697***	
	Forest	337,775	45.8
	Rangeland	242,624	32.9
	Agriculture	102,253	13.9
	Water	38,783	5.3
	Residential	13,411	1.8
	Transitional Areas	2,298	0.3
	Wetlands	555	0.1
Colusa Basin	***Total Acres***	***1,030,498***	
	Agriculture	664,204	64.5
	Rangeland	182,997	17.8
	Forest	167,532	16.3
	Residential	13,866	1.3
	Transitional Areas	819	0.1
	Wetlands	558	0.1
	Water	523	0.1
Sacramento / Feather Rivers	***Total Acres***	***12,588,890***	
	Forest	8,425,556	66.9
	Rangeland	2,249,455	17.9
	Agriculture	1,364,087	10.8
	Water	218,740	1.7
	Residential	135,477	1.1
	Transitional Areas	105,402	0.8
	Wetlands	83,877	0.7
	Perennial Snowfields	5,733	0.05
	Shrub and Brush Tundra	561	0.005

Source: USGS, 1994. GIRAS Land use / Land cover data for the Conterminous United States by quadrangles at scale 1:250,000

Land Uses in the Yolo Bypass

Land use within the Bypass is restricted by flood easements held by the Sacramento-San Joaquin Drainage District. These easements do allow for the use of the land within the Bypass for duck clubs and agriculture. The primary seasonal crops are rice, safflower, tomatoes, corn and other grains. Farming activity is concentrated in spring (following any wet season flooding) and summer. Seasonal uses in the Bypass are portrayed in Figure 4.

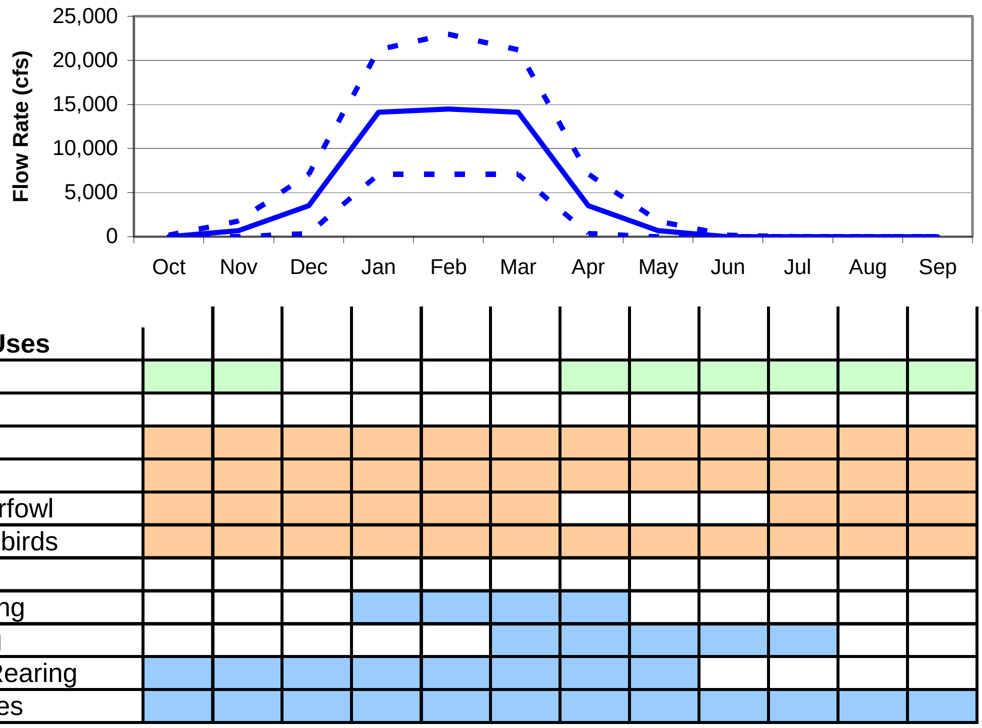


Figure 4. Seasonal uses of the Yolo Bypass (Sommer et al., 2001). The flow rates presented in the graph at top represent normal (solid line) and extreme (upper and lower dashed lines) years.

Approximately one-third of the Bypass is a mosaic of ponds and other uncultivated areas. The largest of these is the Yolo Bypass Wildlife Area, encompassing over 16,000 acres around I-80. The Bypass is a critical link on the Pacific Flyway bird migration corridor. Its waterways supply valuable aquatic habitat to several fish species. Land uses in the Bypass are described in greater detail by the Yolo Bypass Working Group et al. (2001).

Current and potential future recreational uses of water in the Bypass, generally in order of more popular first, include: bank fishing, recreational boating. Some have identified swimming as a recreational use of the Bypass; however, surveys have not been able to document any swimming activities. Hunting, although limited to certain seasons and locations, is also popular. Other outdoor recreational activities include wildlife viewing, hiking/walking, biking, photography, and sunbathing (Jones & Stokes and LWA, 2000).

MONITORING PROGRAM

The monitoring program was designed to characterize major source waters to the Bypass along with in-Bypass processes. The program spanned a full water year to characterize seasonal variability. Monitoring was based on individual “grab” samples collected on a monthly basis from local surface waters, with analysis for chemical constituents and aquatic toxicity testing on a subset of samples. Limited toxicity testing and chemical analyses of streambed sediments were also performed. This section describes the monitoring program. Subsequent sections summarize and assess the monitoring results, leading to a prioritization of the POCs.

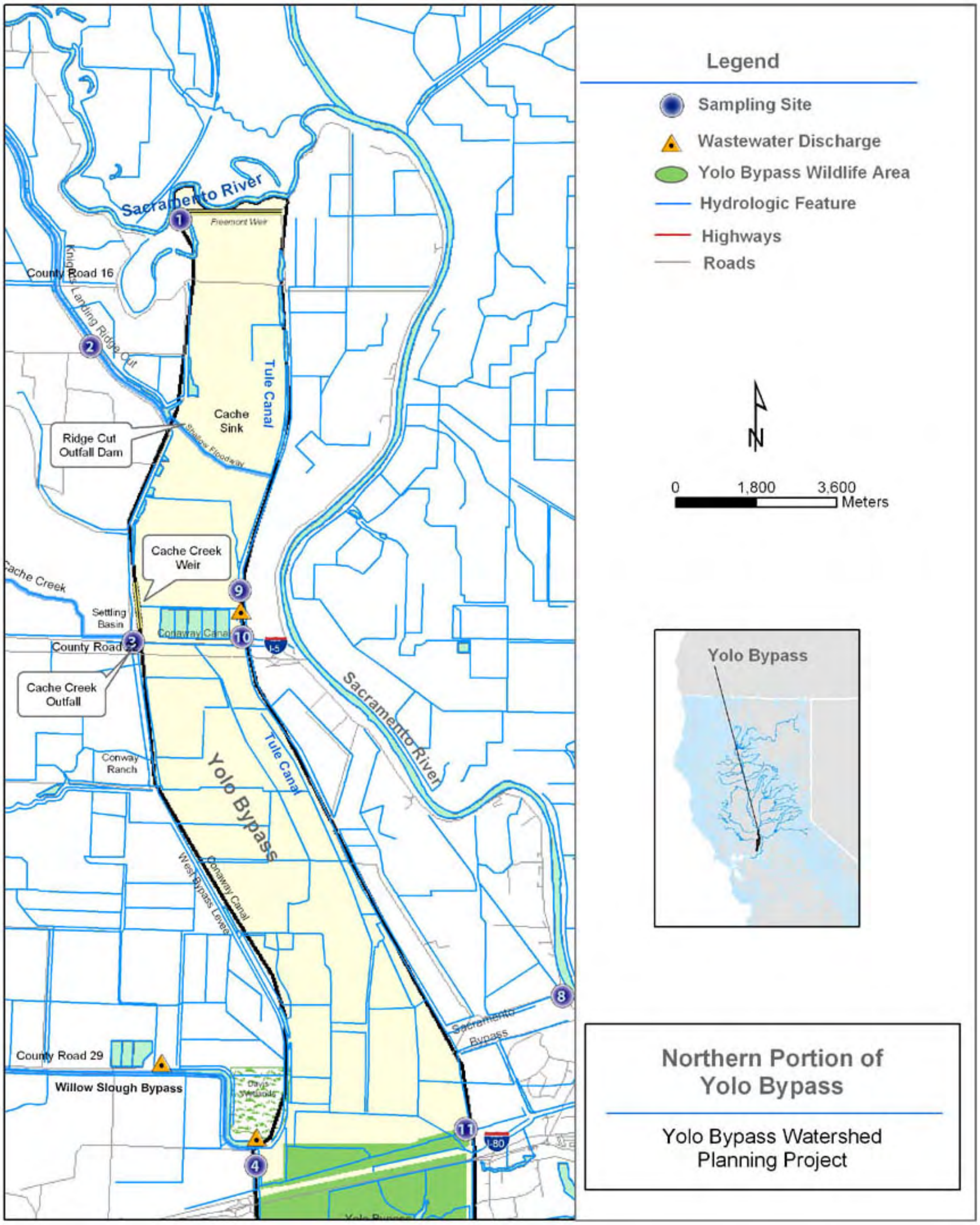
Description of Monitoring Stations

The monitoring program included monitoring at 12 locations in the Yolo Bypass. Eight sites are located at outfalls of major channels or creeks (inputs) flowing into the Bypass, including two sites at flood weirs. Four sites are located along the perennial channel, Tule Canal and the Toe Drain. The Yolo Bypass Wildlife Area (YBWA) site represents water pumped up from the Toe Drain, not in or drained from the YBWA. The Yolo Bypass monitoring sites are listed in Table 5 and illustrated in Figure 5. Photographs of each monitoring site are included in Appendix 4.

Table 5. Description of Yolo Bypass Monitoring Sites

Site description	Site ID	Site Type
Sacramento River Overflow at Fremont	1	Input – Sac R overflow
Knight’s Landing Ridge Cut	2	Input - channel
Cache Creek	3	Input - creek
Willow Slough Bypass	4	Input - channel
Yolo Bypass Wildlife Area – lift pump	5	East side drain channel[1]
Putah Creek	6	Input - creek
Z Drain – Dixon RCD	7	Input - channel
Sacramento Weir	8	Input – Sac R overflow
Tule Canal – Woodland R1	9	East side drain channel
Tule Canal – Woodland R2	10	East side drain channel
Tule Canal at north-east corner of I-80	11	East side drain channel
Toe Drain at north-east corner of Little	12	East side drain channel

[1] This site contains recirculated water pumped from the Toe Drain.


Legend
Sampling Site
Wastewater Discharge
Yolo Bypass Wildlife Area
Hydrologic Feature
Highways
Roads
0 1,800 3,600 Meters
Yolo Bypass
Northern Portion of Yolo Bypass
Yolo Bypass Watershed Planning Project
Sacramento River
Freemont Weir
County Road 16
Knights Landing Ridge Cut
Tule Canal
Cache Sink
Ridge Cut Outfall Dam
Shallow Floodway
Cache Creek Weir
Cache Creek
Setting Basin
Conaway Canal
County Road 22
Cache Creek Outfall
Conway Ranch
Yolo Bypass
Sacramento River
West Bypass Levee
Conaway Canal
Sacramento Bypass
County Road 29
Willow Slough Bypass
Davis Wetlands

a)

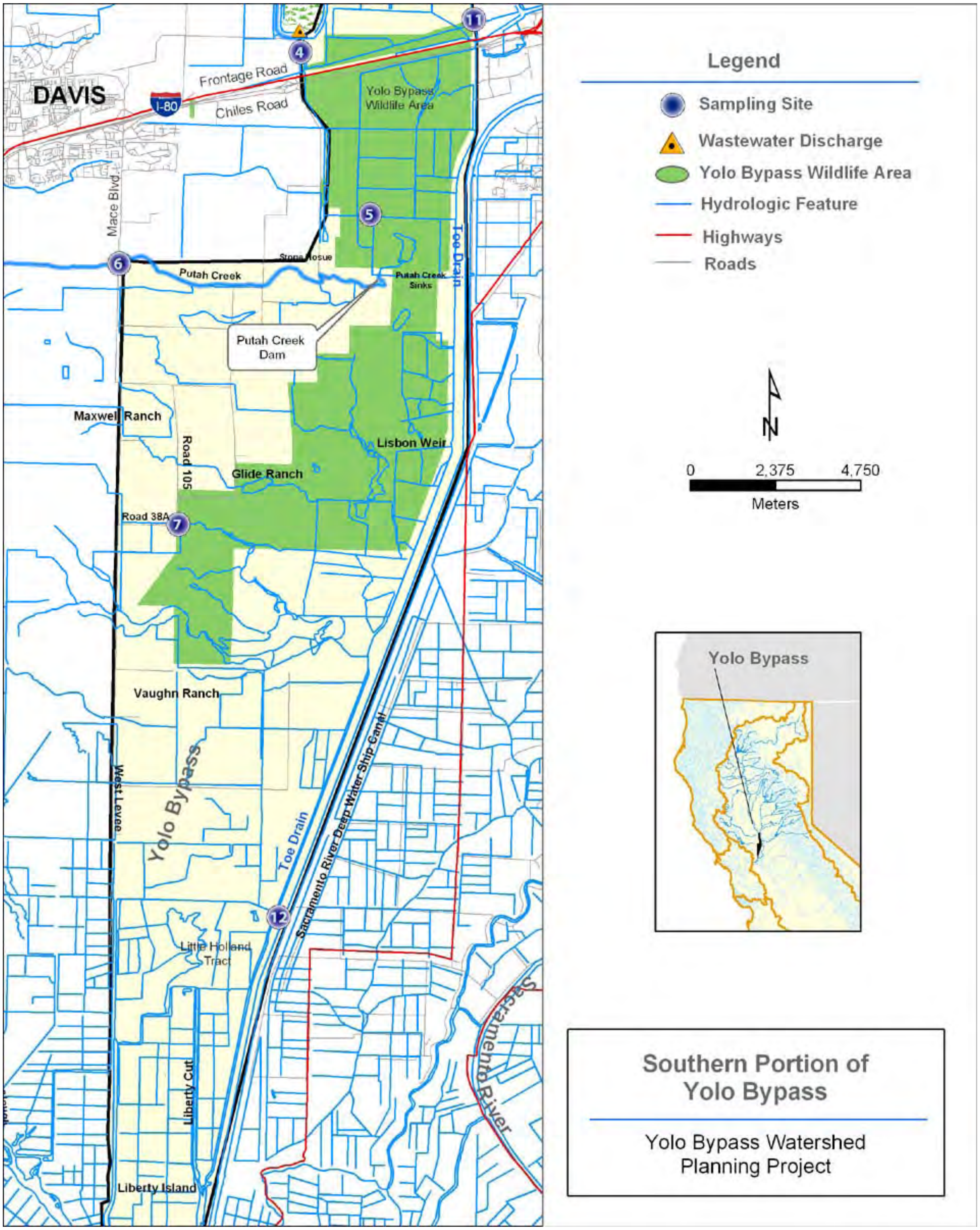
b) 

Figure 5. Map of Yolo Bypass water quality monitoring stations for a) northern and b) southern portion.

Sampling and Analysis Methods

Sampling and analysis methods are described here.

Quality Assurance Program Plan

The types of quality control assessments used in the Yolo Bypass Monitoring Program are discussed below. Detailed procedures for preparation and analysis of quality control samples are provided in the program's Quality Assurance Project Plan (Appendix 5).

Site Observations

Site observations were made by field crews before, during, and after each sampling event and noted on the field log. Observations included anything that may potentially impact sample results or that may aid in interpretation of data and/or the collection of samples in future sampling events.

Field Measurements

Field measurements were collected at each site for each event, and included the following measurements: turbidity, pH, temperature, and electrical conductivity, dissolved oxygen.

Water Column Samples

Grab samples were collected monthly from each site. Grab samples were collected directly into individual containers for shipment. "Clean sampling" techniques were used for the collection of all water samples in a way that does not contaminate, lose, or change the chemical form of the analytes of interest. Samples intended for mercury analysis were collected using rigorous protocols, based on USEPA Method 1669.

The monitoring program conducted chronic (seven-day), three-species toxicity tests quarterly at four sites: Ridge Cut, Cache Creek, Willow Slough, and Tule Canal. These samples were taken concurrently with water quality samples at the same sites and analyzed for metals, mercury, methylmercury, and pesticides. In addition, the program assisted the Yolo County Farm Bureau with collecting samples for acute (96-hour) toxicity tests in support of a separate monitoring program. Acute toxicity samples were collected at the Z Drain, Tule Canal, and Toe Drain sites for five events (June through October).

Streambed Sediment Samples

Fine sediments were sampled from streambeds at ten sites in September 2004. Samples from six of these sites (Ridge Cut, Cache Creek, Willow Slough, Putah Creek, Tule Canal, and Toe Drain) were tested for pesticides, metals, mercury, methylmercury, and chronic toxicity, while the other four (Woodland R1, Woodland R2, YBWA, and the Z Drain) were tested only for mercury and methylmercury. Sampling teams collected approximately the top 2 cm of fine surface sediment from the stream bottoms where sediment accumulated. Monthly water quality samples for September were collected concurrent with the sediment collection.

Sampling Schedule and Review of Monitoring Events

The constituents monitored are shown in Table 6. The sampling schedule is shown in Table 7. Laboratory services were provided by Aqua Science of Davis, CA, CalTest Analytical Laboratory of Napa, CA, Frontier GeoSciences of Seattle, WA, Pacific Ecorisk of Martinez, CA, and BioVir Laboratories of Benicia, CA.

Water column samples were collected on the third week of every month for 12 consecutive months. For all events, 10 sites were visited for collection of field measurements, bacteria and mercury samples. For six of the events, distributed in time, a 'full suite' of samples was collected at several sites: Ridge Cut, Cache Creek, Willow Slough, Putah Creek, Tule Canal, and Toe Drain. The full-suite set of analytes included metals, nitrate, hardness, color, TDS/TSS, TOC/DOC, mercury, methylmercury, bacteria, and pesticides. Four of these six events included the additional collection of chronic, 3-species toxicity samples. During flood conditions (only February 2004) mercury and bacteria samples were collected at the Fremont Weir and Sacramento Weir sites. Flood conditions during this event did not permit access to the Toe Drain or YBWA sites.

Table 6. Summary of constituents and parameters monitored by the project. Sample sites and number of events are shown.

Analyte	Sites	Events
Water Column		
Organophosphate Pesticides by EPA 614/8141	6	6
Chlorinated Pesticides by EPA 608/8081	6	6
Carbamates by EPA 632/8032	6	6
Ultra Trace Mercury (total)	10	12
Methyl Mercury	6	6
Metals (Al, B,Cu, Be, CrIII, Pb, Se)	6	6
Nitrate	6	6
Hardness	6	6
Color	6	6
TDS	6	6
TOC	6	6
DOC	6	6
TSS	6	6
Total & Fecal Coliform, and *E. coli*	10	12
3-Species Chronic Toxicity	4	4
Field Measurements		
Electrical Conductivity	10	12
Turbidity	10	12
Dissolved Oxygen	10	12
pH	10	12
Temperature (F)	10	12
Sediment		
Organophosphate Pesticides by EPA 614/8141	6	1
Chlorinated Pesticides by EPA 608/8081	6	1
Carbamates by EPA 632/8032	6	1
Ultra Trace Mercury (total)	10	1
Methyl Mercury	10	1
Metals (Al, B,Cu, Be, CrIII, Pb, Se)	6	1
TOC	10	1
2-Species Chronic Toxicity	6	1

Table 7. Sampling schedule for analytes by site and event.

SITE Class	SITE No.	EVENTS Nov 1	Dec 2	Jan 3	Feb 4	March 5	April 6	May 7	June 8	July 9	Aug 10	Sept 11	Oct 12
Inputs	1				1, 2, 4								
	2	1, 2, 3, 4	1	1, 2, 3, 4, 5	1	1	1, 2, 3, 4, 5	1	1, 2, 3, 4	1,	1, 2, 3, 4, 5	1, 2. 3, 4, 5	1
	3	1, 2, 3, 4	1	1, 2, 3, 4, 5	1	1	1, 2, 3, 4, 5	1	1, 2, 3, 4	1	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1
	4	1, 2, 3, 4	1	1, 2, 3, 4, 5	1	1	1, 2, 3, 4, 5	1	1, 2, 3, 4	1	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1
	5	1	1	1			1	1	1	1	1	1	1
	6	1, 2, 3, 4	1	1, 2, 3, 4	1	1	1, 2, 3, 4	1	1, 2, 3, 4	1	1, 2, 3, 4	1, 2, 3, 4	1
	7	1, 3	1	1, 3	1	1	1, 3	1	1, 6	1, 6	1, 3, 6	1, 3, 6	1, 6
	8				1, 2, 4								
East Channel	9	1, 3	1	1, 3	1	1	1, 3	1	1	1	1, 3	1, 3	1
	10	1	1	1	1	1	1	1	1	1	1	1	1
	11	1, 2, 3, 4	1	1, 2, 3, 4, 5	1	1	1, 2, 3, 4, 5	1	1, 2, 3, 4, 6	1, 6	1, 2, 3, 4, 5, 6	1, 2, 3, 4, 5, 6	1, 6
	12	1, 2, 3, 4		1, 2, 3, 4		1	1, 2, 3, 4	1	1, 2, 3, 4, 6	1, 6	1, 2, 3, 4, 6	1, 2, 3, 4, 6	1, 6

1 = Total Mercury and Total and fecal coliforms, including E. Coli (10/12)
2 = Methylmercury and Trace Metals (6/6)
3 = Pesticide group: Chlorinated, organophosphatesm and carbamates (6/6)
4 = General constituents: Hardness, TOC, DOC, TSS, TDS, Color, and Nitrate (6/6)
5 = Chronic 3-Species Toxicity (4/4)
6 = Acute 3-Species Toxicity, TSS/TDS, Color, TOC/DOC, UV Absorption (3/5)

Grey indicates site sampled only when weir is breached

Summary of Monitoring Results

The analytical results for water column and streambed sediment samples are presented in Appendix 6-A. Descriptive statistics of the water column monitoring data are presented in Appendix 6-B. For pesticides, only detected chemicals are tabulated. Because of the small number of samples, there was no attempt to develop statistical distributions of the data. To calculate mean values, non-detected values are assumed to be half of their detection limit. Also, exceedances of water quality objectives are quantified as the number of detected samples exceeding the applicable criterion. An assessment of water quality based on these results is presented in the next section.

Water Column Samples

Six samples from six sites were analyzed for total and dissolved metals, total and dissolved solids, nitrate, boron, hardness, methylmercury, organic carbon, and pesticides (OCs, OPs, and carbamates). Total mercury, bacteria, and conventional parameters (EC, temperature, DO, color) were analyzed almost monthly at all 12 sites. Access to the Yolo Basin Wildlife Area and the Toe Drain sites was not possible on two occasions.

Water column samples from four representative sites were analyzed on four events for chronic toxicity. Water column samples from three representative sites were analyzed on five events for acute toxicity. One sample from each of three sites – Ridge Cut, Z Drain, and Toe Drain exhibited toxicity to fathead minnows only. No other samples exhibited acute or chronic toxicity to the test organisms.

Streambed Sediment Samples

Streambed sediment samples were collected for the September 2004 sampling event at six sites and analyzed for metals, organic carbon, and a full suite of OP, OC, and carbamate pesticides. Aluminum content in sampled sediments was lower than in water column samples. Mercury content was high in Putah Creek (0.6 mg/kg) but low elsewhere. The next highest mercury content was Cache Creek, with a content of 0.22 mg/kg, approximately the content in native soil. Other metals analyzed were either nondetected or not of concern. All samples were below analytical detection limits for pesticides except for one sample from Putah Creek having detectable 4,4'-DDE.

Streambed sediment samples were tested for chronic toxicity on one event. Significant survival and growth effects on both test organisms (the amphipod *Hyalella azteca* and the midge *Chironomus tentans*) were found for the Knights Landing Ridge Cut site. In addition, survival and growth of the midge was significantly lower in samples from Tule Canal, Putah Creek, and Toe Drain.

Flow Rate Estimates

Flow rates at each sampling site were estimated for each event by various methods. The estimated flow rates are shown in Table 8. Accurate estimates during low-flow conditions were often not feasible at several sites. One inconsistency observed is that estimated flow rates decrease downstream from Fremont Weir to Tule Canal during the wet season. The Bypass is considered "flooded" when flow rate exceeds approximately 3500 cfs. This level was exceeded during the monitoring period only in February.

Table 8. Estimated flow rates (in cubic feet per second) at sampling sites during sampling.

Site Name:	Fremont Weir	Ridge Cut	Cache (CCY, Yolo)	Willow Slough Bypass	YBWA	Putah Cr.	Z Drain	Sacra-mento Weir	Tule Canal (R1)[4]	Tule Canal (R2)	Tule Canal (I-80)	Toe Drain (Lisbon)
Site #:	1	2	3	4	5	6	7	8	9	10	11	12
Area (acres):	13,000,000	1,000,000	740,000	103,000	n/a	440,000	20,000	n/a	n/a	n/a	n/a	n/a
Date												
11/23/03	*	12	4	< b		21	1		140	140		< a
12/20/03	*	nr	97	3		70	1		904	904		< a
01/23/04	*	15	62	18		126	2		895	895		1,749
02/21/04	73,570	nr	3,620	nr		235	<1		45,800	45,800		3,367
03/27/04	*	nr	332	10		235	2		950	950		1,938
04/23/04	*	< b	49	1		85	<1		355	355		686
05/22/04	*	< b	8	60	[1]	58	20	[2]	< a	< a	[3]	189
06/26/04	*	< b	10	28		43	22		< a	< a		24
07/24/04	*	< b	15	15		35	10		< b	< b		61
08/20/04	*	< b	< b	17		35	11		< b	< b		155
09/21/04	*	< b	5	< b		8	35		< a	< a		146
09/22/04	*	< b	5	< b		11	35		< a	< a		118
10/23/04	*	nr	40	< b		13	6		< a	< a		67

* No water
nr = not recorded
< below detection limit of field meter or gage:
a. USGS or DWR Gage Limit is 100 cfs.
b. Marshall-McBirney Flowmate 200 Field Flow Meter, reading less than 1 ft/s.
[1] Water is pumped into the wetlands from a canal connected to the Toe Drain. Withdrawn water is pumped to farmland west of the Bypass or recycled.
[2] Water did flow over the Sacramento Weir in Feburary 2004, but flow rates are not reported.
[3] Flows at this site were not measured because of logistic constraints.
[4] Flows at R-1 are essentially equivalent to measured flow at R-2 minus City of Woodland effluent discharges, which average less than 15 cfs.

ASSESSMENT OF CURRENT WATER QUALITY

Current water quality is assessed for the specific POCs in each pollutant category that indicate some potential for exceedances of water quality criteria. The assessments are based primarily on the data collected during this study but also consider historical data. This section concludes with a prioritization of the POCs based on this analysis.

The format for assessing each type of POC is as follows.

- Describe the POCs and the basic issues that they present – reiterating some of the reasoning for selecting the POCs while providing additional context for the assessment.
- Assess any spatial patterns discernible in the dataset for 12 monitoring stations – compare concentrations for groups of sites:
  - **"AgDrain":** Agricultural drains of Knights Landing Ridge Cut, Willow Slough Bypass, and Z Drain;
  - **"Flood":** Sporadic flood discharges over Fremont Weir and Sacramento Weir;
  - **"InBypass":** In-Bypass flows in Tule Canal (sites R-1, R-2, and I-80), Yolo Basin Wildlife Area, and the Toe Drain; and
  - **"WestTrib":** Regularly-flowing west-side tributaries of Cache Creek and Putah Creek.
- Assess any temporal patterns discernible in the dataset for 12 monitoring events – compare concentrations and loads for events and seasons:
  - Flood events (February data for the two weir sites);
  - Wet season (December – April); and
  - Dry season (May – November).
- Describe in general terms the conceptual model, identifying likely sources and sinks to which the patterns can be attributed.

A POC could be associated with suspended material because of several reasons, including: it is a natural component of soil, it is applied to or deposited on soil and enters water concurrent with soil erosion, and it adsorbs to soil or suspended organic material. Correlations between various POCs and TSS or discharge are generally not feasible because TSS was measured on only six occasions and discharge was immeasurably low at many sites much of the year. But POCs are compared to TSS and discharge at selected sites to identify any potential correlations.

Spatial and temporal patterns in the Bypass are summarized in Table 9 based on average concentrations. Consistent with the data summaries presented in the previous section, one-half of the detection limit was substituted for non-detected values. For pesticides, which were rarely detected, the values presented are the averages of detected samples only.

Table 9. Average water column concentrations for POCs grouped by site characterization and season.

		Characterization[1]=	AgDrain			Flood	InBypass			WestTrib		
		Season[2]=	All	Wet	Dry	n/a	All	Wet	Dry	All	Wet	Dry
POC	Units	Criteria[3]										
Averages of all values												
E. Coli	MPN/100mL	126	4,215	4,643	3,754	4,000	1,355	2,266	562	599	535	928
Fecal Coliform	MPN/100mL	200	4,991	4,192	5,121	6,000	1,995	2,936	1,299	651	539	1,012
Total Coliform	MPN/100mL	--	43,961	25,045	61,605	8,000	25,653	24,146	25,738	10,222	5,223	14,474
Boron	ug/L	700	1,347	1,053	1,494	NA	934	650	1,076	1,062	973	1,106
Boron, dissolved	ug/L	--	1,320	970	1,495	NA	818	610	921	926	940	919
Aluminum	ug/L	87	1,958	1,575	2,150	NA	2,575	2,400	2,663	883	545	1,053
Aluminum, dissolved	ug/L	--	7.1	11.3	5.0	NA	11.7	17.5	9	7.1	7.5	7
Chromium(III)	ug/L	340	7.3	5.2	8.4	NA	9.0	8.2	9	5.4	5.1	6
Chromium(III), dissolved	ug/L	395	1.47	1.48	1.46	NA	1.17	1.60	1	2.53	3.73	2
Copper	ug/L	18.3	6.6	6.0	6.9	NA	7.6	7.3	8	3.5	2.8	4
Copper, dissolved	ug/L	17.6	2.62	2.75	2.55	NA	2.77	2.63	3	1.66	1.53	2
Lead	ug/L	8.68	1.15	0.95	1.25	NA	1.17	1.18	1	0.53	0.35	1
Lead, dissolved	ug/L	5.9	0.15	0.19	0.13	NA	0.15	0.19	0.1	0.14	0.19	0.1
Methylmercury	ng/L	0.06	0.34	0.28	0.38	NA	0.33	0.49	0.26	0.33	0.38	0.30
Total Mercury	ng/L	51	9.4	6.7	11.7	22	13.7	12.6	14	10.5	10.3	10
Selenium	ug/L	5	2.8	2.6	2.9	NA	0.91	1.13	1	1.13	0.73	1
Selenium, dissolved	ug/L	--	2.5	2.3	2.6	NA	0.98	1.00	1	0.85	0.93	1
Nitrate	mg-N/L	10	0.73	0.41	0.89	NA	1.72	0.60	2	3.10	2.98	3
Total Organic Carbon	mg/L	--	8.6	10.5	8.0	NA	7.5	7.5	8	4.8	4.8	5
Dissolved Organic Carbon	mg/L	--	8.2	7.8	8.3	NA	7.1	7.5	7	4.7	4.8	5
EC	umhos/cm	700	797	786	787	120	607	548	661	532	514	542
TDS	mg/L	450	494	485	498	NA	381	335	400	328	328	329
TSS	mg/L	--	69	55	74	NA	58	62	56	21	22	21
Averages of detected values												
Diuron	ug/L	10	0.32	0.55	0.17	NA	0.30	0.40	0.10	ND	ND	ND
Methomyl	ug/L	0.52	ND	ND	ND	NA	ND	ND	ND	0.7	0.7	ND
4,4'-DDE	ug/L	0.00059	0.01	ND	0.01	NA	ND	ND	ND	ND	ND	ND
Chlorpyrifos	ug/L	0.009	0.03	0.04	0.01	NA	ND	ND	ND	0.02	0.02	0.02
Diazinon	ug/L	0.1	0.03	0.03	ND	NA	ND	ND	ND	0.04	ND	0.04

[1] Sites aggregated into these site categories are indicated in the text.
[2] "Wet" season includes December-April; "dry" season is all other months.
[3] Indicating lowest potentially applicable criteria, as presented in the report.
"NA" indicates that no data are available; no samples were collected.
"ND" indicates that all samples were nondetected.

Bacteria

Bacteria indicators were monitored to represent the potential presence of pathogens. Bacteria were measured as total coliform, fecal coliform and *E. coli* concentrations in water column samples. These bacteria may come from human as well as domestic animals and wildlife feces; therefore, sources can not be positively identified. These bacteria indicators are also naturally present in soil and may degrade or proliferate depending on their aquatic environment. The local concern is with humans recreating in the Bypass waters and the use of such waters to irrigate agricultural food crops. Contact with human skin can cause rashes, while ingestion can cause illness. The concern in the Delta is for the protection of drinking water sources.

Bacteria were among the POCs monitored monthly at all 12 sites. The criteria are based on the geometric mean of multiple samples taken during a 30-day period, but are compared to the individual sample results and to average values for sampling sites. Almost all fecal coliform were determined by analyses to be *E. coli*.

Spatial Patterns

The two agricultural drains Willow Slough Bypass and Z Drain had among the three highest median concentrations of all three bacteria indicators. The two west-side Cache and Putah Creeks ranked among the lowest concentrations of all three bacteria indicators. Flows over the Fremont and Sacramento Weirs, sampled only once, were within the range of concentrations measured elsewhere on the same occasion. In-Bypass sites had concentrations ranking in the middle to lower third of the sites and do not portray any consistent downstream pattern. All sites exceeded the 200 MPN/100mL objective for fecal coliform on at least one occasion. Concentrations in the agricultural drains Willow Slough Bypass and Z Drain regularly exceeded the proposed 126 MPN/100mL objective for *E. coli*. All other sites except the Yolo Basin Wildlife Area exceeded the proposed objective at least once.

Temporal Patterns

Bacteria indicators did not portray any clear seasonal patterns. Bacteria indicators are notoriously variable in the environment, and the data collected during this study is consistent with that pattern. Data for several sites indicate fluctuations of two orders of magnitude in fecal coliform and *E. coli* from one month to the next.

Conceptual Model

Bacteria concentrations were measured highest in runoff from rural areas. Total coliform is very poorly correlated with TSS data for the Willow Slough Bypass (Figure 6), indicating that eroded soil may not be the main contributor. Wildlife using the Bypass throughout the year could have caused bacteria levels in the Bypass to remain steady. Degradation and sequestration in local soil are dominant sinks or losses of bacteria.

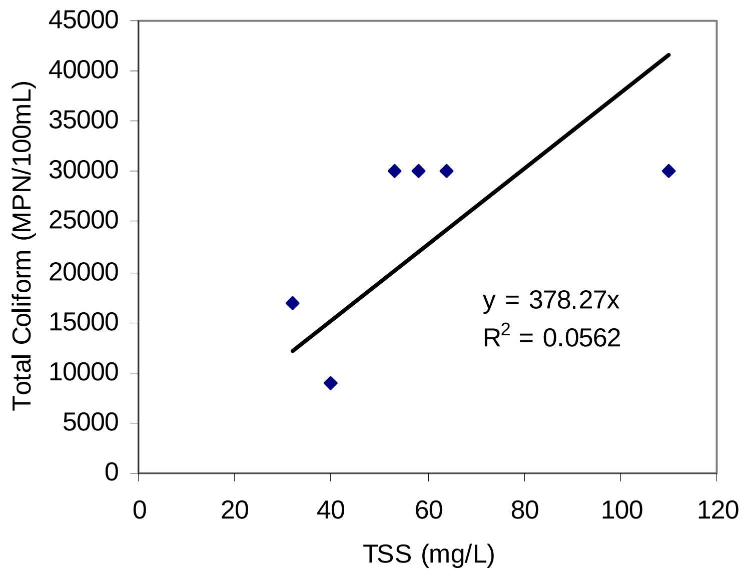


Figure 6. TSS versus total coliform concentrations in Willow Slough Bypass samples. There is no criterion for total coliform.

Boron

Boron was monitored to identify potential sources and seasonal conditions. Boron has many properties similar to salinity. Boron is a concern because of potential impacts to agricultural production.

Spatial Patterns

Boron concentrations do not portray any clear spatial patterns. Cache Creek had the highest median concentration among all sample sites while its southern neighbor Putah Creek had the lowest. Only Putah Creek had average boron concentrations below the 700 ug/L criteria. Willow Slough Bypass, between those two tributaries, had the second highest median concentration. Overall, boron concentrations are generally higher than measured previously at the same locations by Schemel et al. (2002). Yet the average boron concentration in Cache Creek is half of the concentration measured regularly by the YCFCWCD (2000).

Temporal Patterns

For each type of monitoring site, average dry season boron concentrations were higher than wet season concentrations. All summertime flow in Cache Creek is diverted at Capay onto local farms, so any/all water passing through the Cache Creek Settling Basin during summer is irrigation tailwater or runoff from groundwater pumping. However, total boron concentrations do not indicate a seasonal or flow-based pattern at the Cache Creek site (Figure 7).

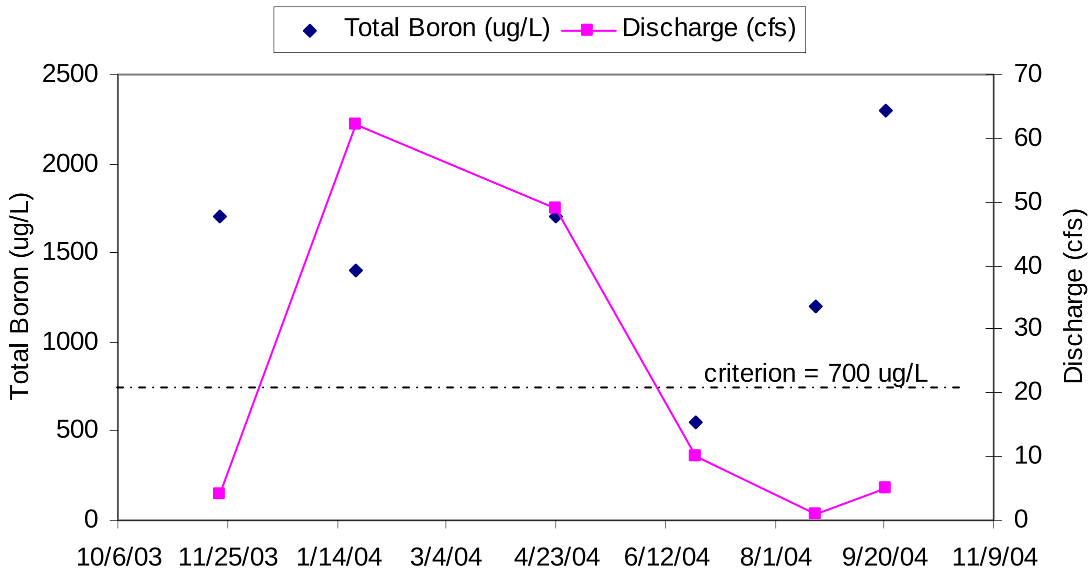


Figure 7. Total boron concentrations and flow rate measured in Cache Creek.

Conceptual Model

Recognizing that dry season concentrations of boron are generally higher than wet season concentrations, potential sources are groundwater wells and groundwater seepage. This condition points to natural marine sediments sources leached into water that eventually becomes surface runoff. Evapotranspiration likely increases concentrations. A better quantification of source waters is needed to verify sources of boron in the Cache Creek watershed.

Aluminum

Aluminum is a metal addressed separately because of the high levels detected.

Spatial Patterns

For the entire project dataset, only one sample (from Putah Creek) was measured *below* the total aluminum criterion of 87 ug/L. Total and dissolved aluminum concentrations were highest at the two most downstream sample sites, Tule Canal at I-80 and the Toe Drain. Total aluminum concentrations at these two sites correlated well with TSS (Figure 8). These data indicate that 4.5% of the TSS is aluminum by weight, which is less than its concentration in benchmark (i.e., undisturbed) soils collected in Yolo County (Bradford et al., 1996) and in tributary sediments (Maccoy and Domagalski, 1999). The dissolved fraction did not correlate with pH levels (not shown). Streambed sediment samples collected in September 2004 did not correlate with median water column concentrations (not shown).

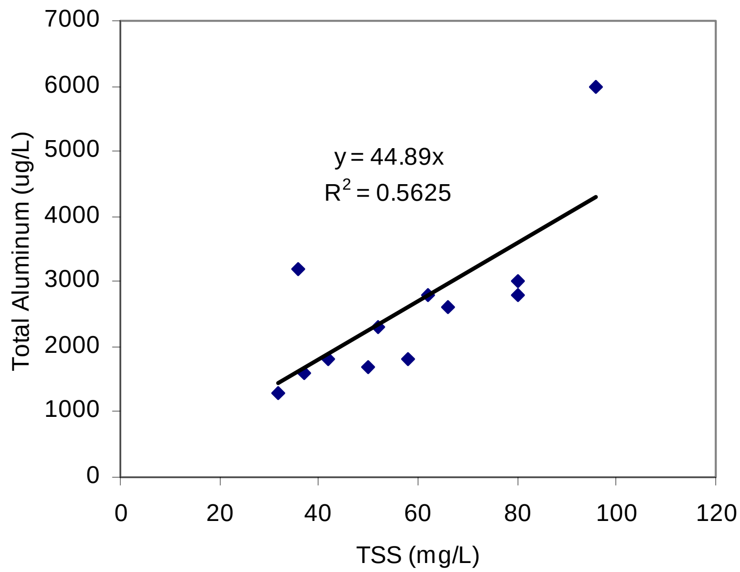


Figure 8. TSS versus total aluminum concentrations for combined Tule Canal at I-80 and Toe Drain sites' data. The criterion of 87 ug/L is indistinguishable at the bottom of the scale of this figure.

Temporal Patterns

Aluminum did not portray any clear seasonal patterns.

Conceptual Model

Aluminum content in TSS is within the range of background soil content. Thus, the primary source of aluminum appears to be native, undisturbed soil. Dissolved aluminum is the form generally considered toxic to aquatic organisms. However, there is no predictable relationship found between total and dissolved aluminum concentrations. The ratios of dissolved to total aluminum for in-Bypass samples are not consistent and do not correlate with instantaneous pH readings.

Mercury

Mercury is a metal addressed separately because of the high levels detected. The regional concern with mercury is accumulation of methylmercury in the food web and transport to the Delta.

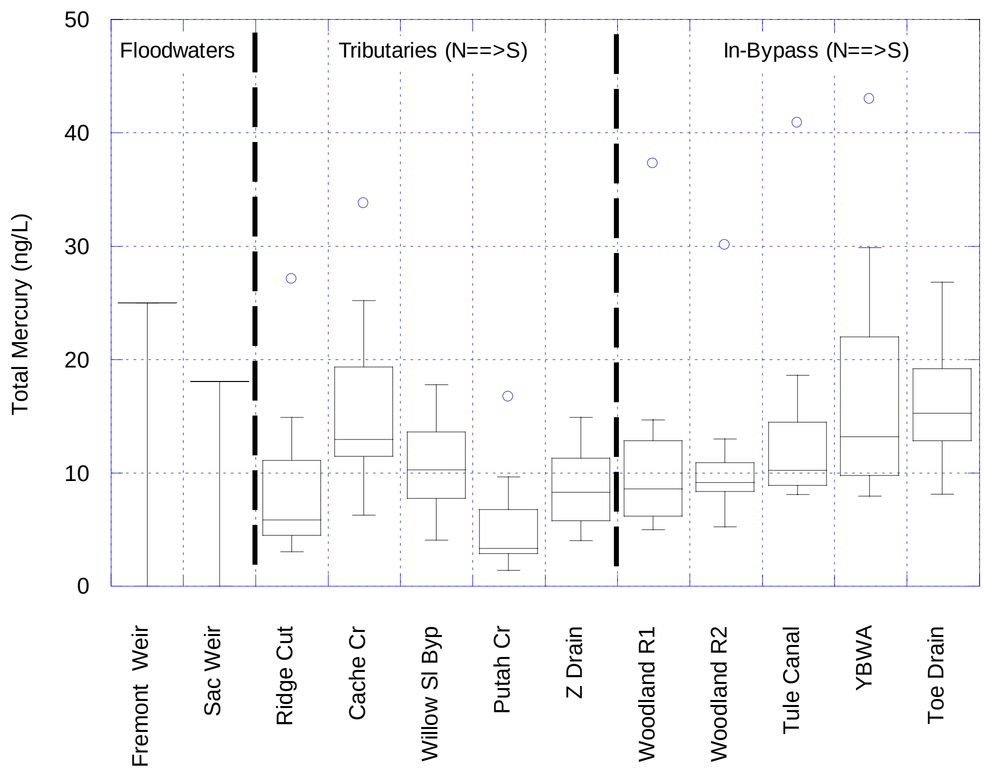
Spatial Patterns

Total mercury and methylmercury concentrations are summarized in Figure 9 as box plots. Total mercury concentrations were higher in flood waters over the Fremont and Sacramento Weirs than in all other sites. Assuming that the single sample of Fremont Weir water is representative of that source, 140 pounds of mercury were discharged into the Bypass during the sampling period. For perspective, this load is approximately 100 times the average annual load from all municipal wastewater treatment plants into the Bypass combined but one-tenth of the total load to San Francisco Bay. The next two highest were the southern-most points in the Bypass, Tule Canal at I-80 and the Toe Drain. Cache Creek had the highest methylmercury concentration while Putah Creek had the lowest.

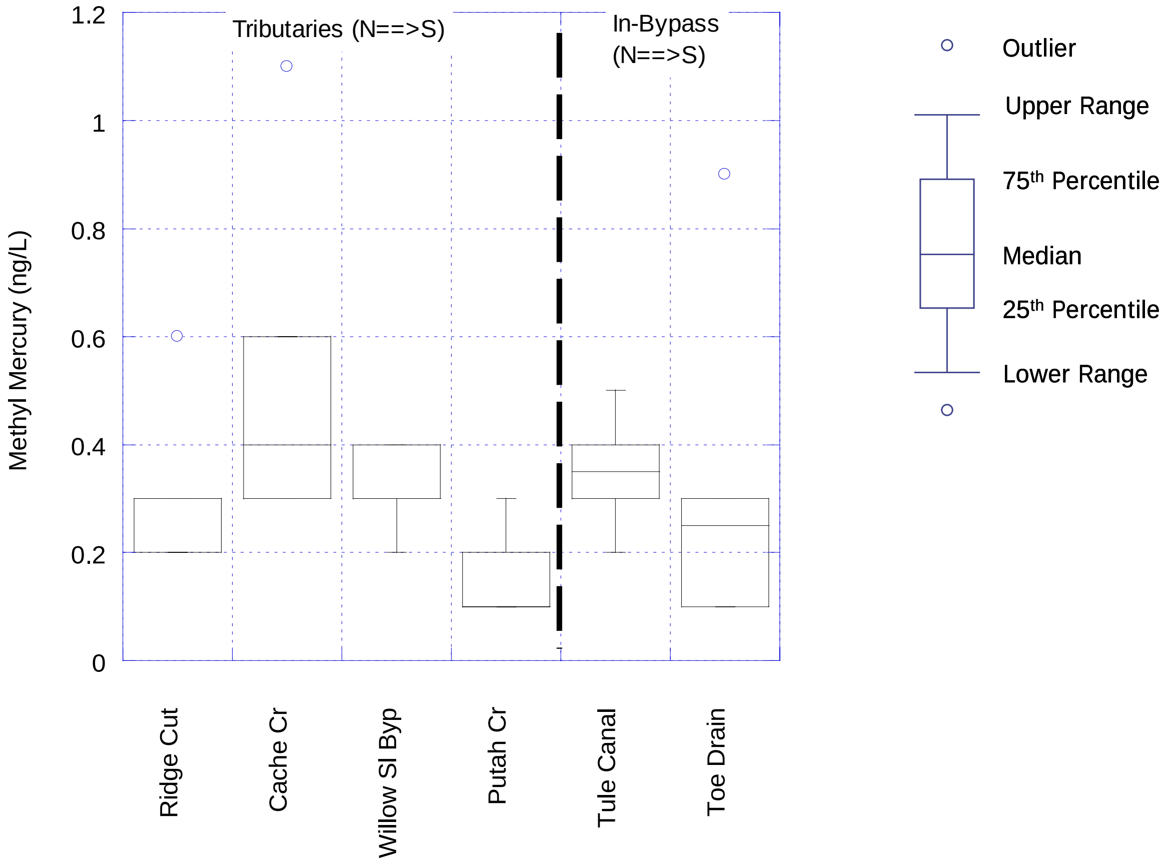
No samples exceeded the applicable total mercury criterion of 51 ng/L, while all samples exceeded the potentially applicable methylmercury criterion of 0.06 ng/L. Within the Bypass, total mercury concentrations consistently increased from upstream to downstream sites. Methylmercury concentrations were monitored within the Bypass only at Tule Canal at I-80 and the Toe Drain. The median methylmercury concentration at the downstream site was lower than at the upstream site, contrary to the expectation that Bypass wetlands would increase methylmercury concentrations. Methylmercury concentrations measured at the in-Bypass sites are consistent with other reported data.

The load of total mercury from Cache Creek to the Bypass was approximately 26 pounds for the 12-month monitoring period, less than 20% of the load from the Fremont Weir which occurred over a roughly one-month period.

Total mercury and methylmercury concentrations are plotted against TSS in Figure 10.

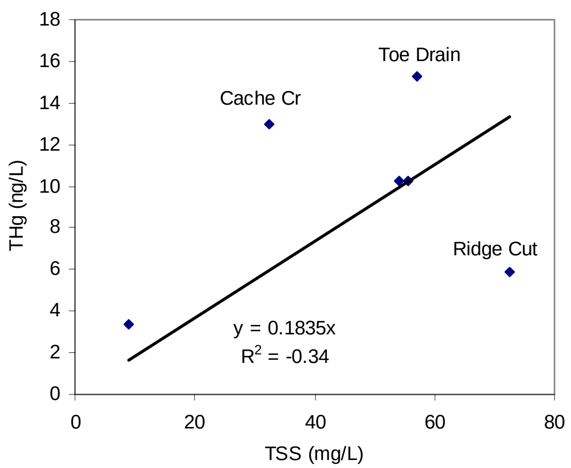


a)

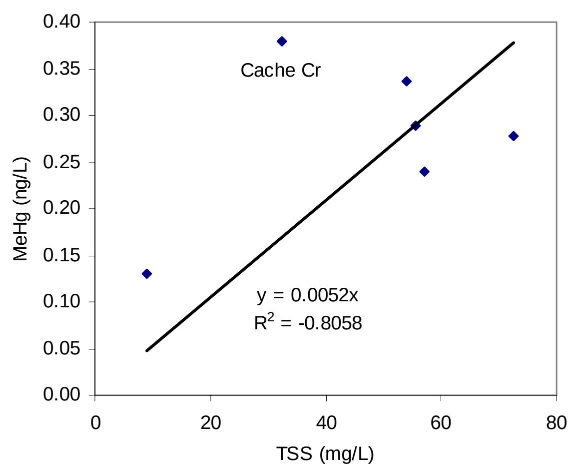


b)

Figure 9. Box plots of a) total mercury and b) methylmercury concentrations at all sample sites.



a)



b)

Figure 10. Average TSS versus average a) total mercury (THg) and b) methylmercury (MeHg) concentrations for all sites monitored for mercury. The linear regressions are not valid, but are used to indicate relative ratios.

A similar comparison among sites can be made for mercury content in sediments (Figure 11). Results for Putah Creek indicate by far the highest content of total mercury but average content of methylmercury. The Yolo Bypass Wildlife Area (YBWA) sample had exceptionally high methylmercury content but average total mercury content. The correlation did not improve by normalizing to TOC, as suggested elsewhere (Krabbenhoft et al., 1999).

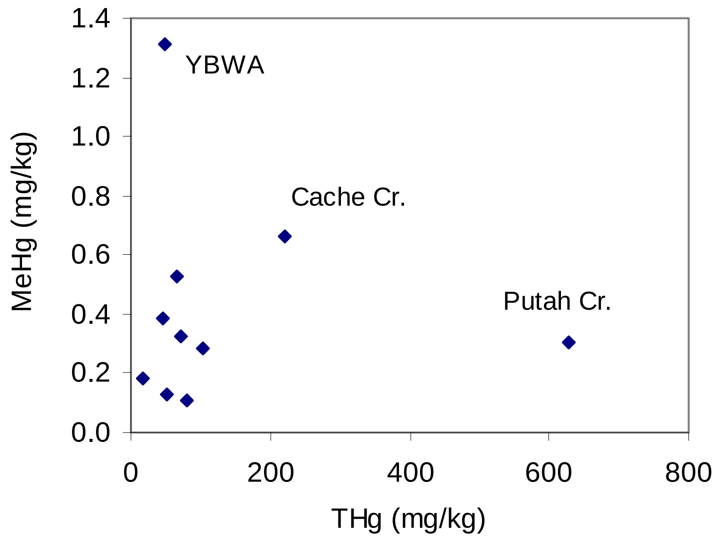
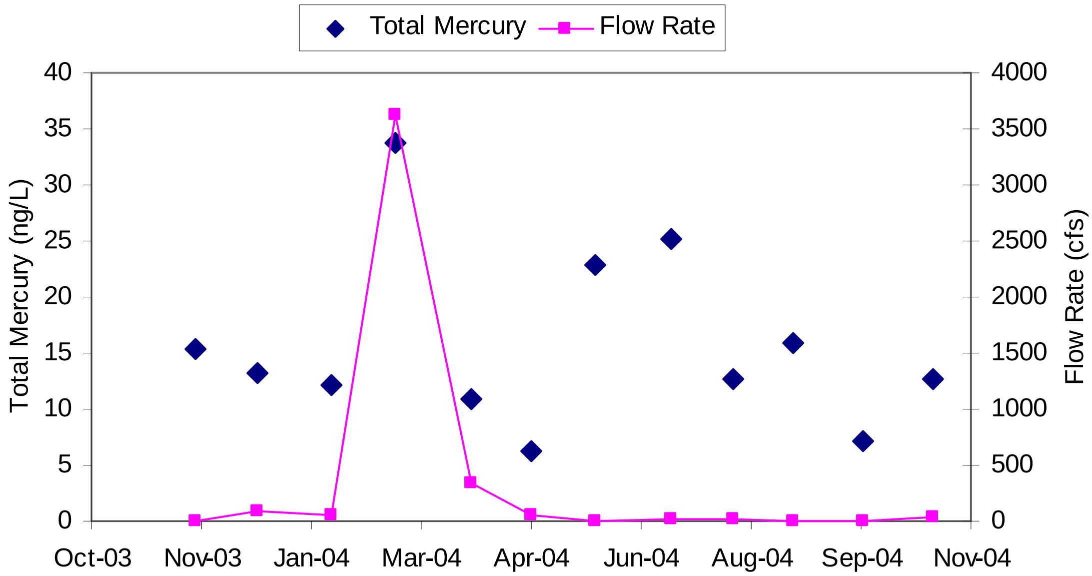


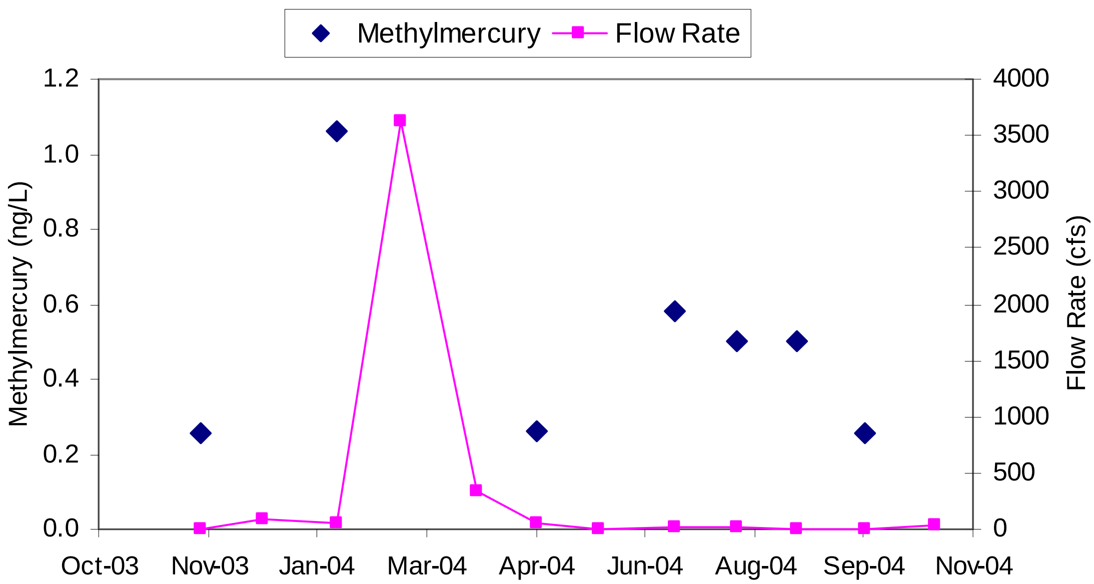
Figure 11. Total mercury (THg) versus methylmercury (MeHg) content in sediments collected at each sample site.

Temporal Patterns

Methylmercury concentrations were higher on average in the wet season than in the dry season in the Bypass and in west-side tributaries. This finding is consistent with the full data record. Total mercury and methylmercury concentrations in Cache Creek are shown in Figure 12. There is no discernible seasonal pattern or correlation with discharges at this site regularly referred to as a major source of mercury in the Bypass.



a)



b)

Figure 12. Concentrations of a) total mercury and b) methylmercury in Cache Creek plotted along with flow rate. The total mercury criterion of 50 ug/L is above the scale on Figure a; the methylmercury criterion of 0.06 ug/L is indistinguishable at the bottom of the scale in Figure b.

Conceptual Model

Mercury sources to water can include the following:

- Atmospheric deposition
- Permitted discharges of treated wastewater

- Erosion of native sediment
- Urban runoff
- Discharges from naturally occurring mineral springs
- Erosion and leaching from inactive mercury mining sites
- Erosion and leaching from historic gold mining sites.
- Re-suspension of contaminated sediments.
- Erosion and leaching of pesticide residue in soils
- Releases from other mineral mines and waste disposal sites

Mercury mines in the Cache and Putah Creek watersheds supplied mercury amalgam for gold mining in the Sierras and other industrial uses. While a portion of the mine waste is still on these abandoned sites, larger volumes of waste now reside downstream in streambank and streambed repositories. High releases from Clear Lake and Indian Valley Reservoir appear to erode large volumes from these repositories along the mainstem of Cache Creek (CVRWQCB, 2004).

Slotton and Ayers (2004) found that the Cache Creek Nature Preserve, discharges from which seep into lower Cache Creek, functions as a source of methylmercury. Mercury levels in fish collected from within the Preserve are elevated; however, monitoring did not indicate any downstream effects. This finding is consistent with the findings from this project's data that methylmercury concentrations did not increase progressing downstream through the Bypass.

Sinks or losses of total mercury and methylmercury include volatilization, sequestration in local soil and biouptake. Losses of total mercury within the Bypass are likely insignificant. Demethylation of methylmercury is likely the major loss mechanism for this form.

Total mercury versus TSS in Cache Creek is plotted in Figure 13. The slope of the linear regression indicates a content of 0.4 ppm, compared to the average content of regional background soil in non-mineralized areas 0.2 mg/kg (Churchill and Clinkenbeard, 2002). This content estimate is consistent with the historical data reported by others and used in the Cache Creek mercury TMDL (CVRWQCB, 2004).

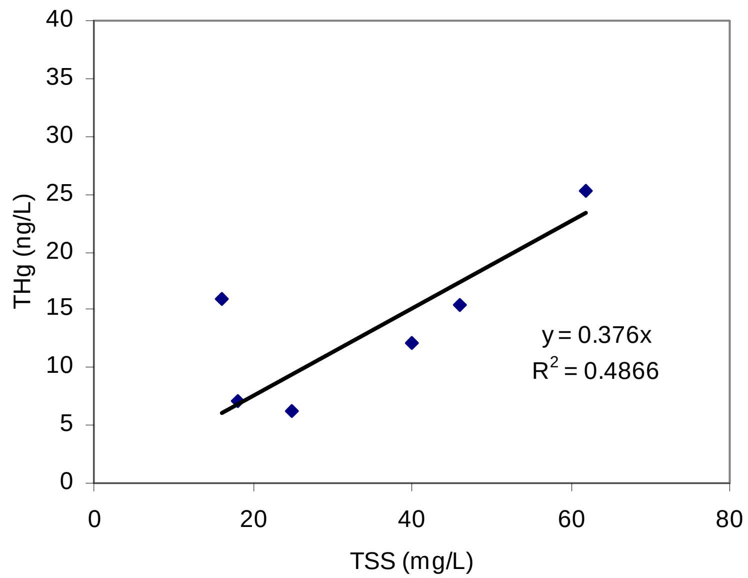


Figure 13. TSS versus total mercury concentrations in Cache Creek. The criterion of 51 ug/L is above the scale of this figure.

Mercury concentrations measured at the two in-Bypass monitoring sites are plotted against concurrent TSS concentrations in Figure 14. The slope of the linear regression in Figure 14a indicates a content of 0.23 ppm, essentially the average content of regional background soil in non-mineralized areas.

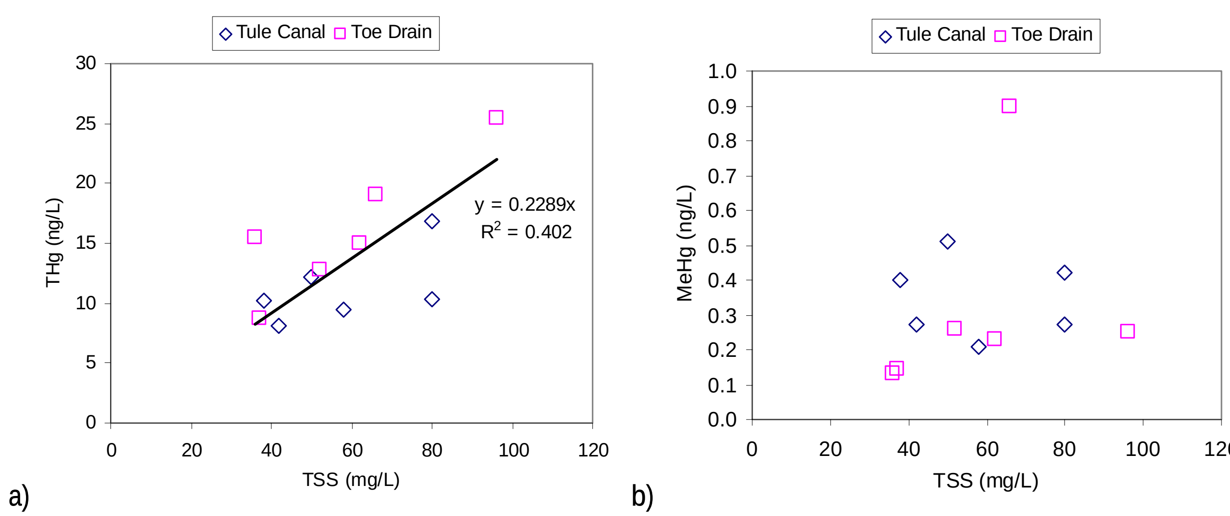


Figure 14. TSS versus a) total mercury and b) methylmercury concentrations in Tule Canal and Toe Drain sample results. Methylmercury is not correlated with TSS.

Other Metals

Other metals are assessed expeditiously because of the low concern for these POCs: chromium, copper, lead, and selenium.

Spatial Patterns

Total and dissolved chromium(III) concentrations were generally an order of magnitude or more below the chromium(III) criterion at all sites.

No samples approached the dissolved copper or lead criteria. The west-side tributaries consistently had the lowest copper and lead concentrations. The two sites lowest in the Bypass, Tule Canal at I-80 and the Toe Drain, tended to have among the highest total and dissolved copper concentrations.

Although three sites had samples measured at or above the selenium criterion (5 ug/L), no sites had average total selenium concentrations at that level. The two agricultural drains Knights Landing Ridge Cut and Willow Slough Bypass has the highest total and dissolved selenium concentrations.

Temporal Patterns

None of the other metals portrayed any clear seasonal patterns.

Conceptual Model

Sinks or losses of other metals include transport in surface water to the Delta, sequestration in local soil and biouptake. Losses of these metals within the Bypass are likely insignificant.

Nitrate

Nitrate is a concern to humans because it causes a potentially lethal blood disorder called Methemoglobinemia, known as “blue baby syndrome”. Nitrate is a concern in surface waters because it can enhance the growth of algae and plants beyond natural or desired levels, in a process called eutrophication. Eutrophication can be detrimental locally if it causes exaggerated daily reductions in dissolved oxygen, leading to fish kills. Eutrophication is detrimental to water supplies primarily by increasing concentrations of filterable algae and causing pH to fluctuate.

Spatial Patterns

Cache and Putah Creeks had the highest nitrate concentrations, although median concentrations were below 1.5 mg-N/L at all sites. These values are substantially lower than the criteria of 10 mg-N/L.

Temporal Patterns

Average nitrate concentrations were lower in the dry season compared to the wet season for each site type.

Conceptual Model

Nitrate concentrations found during this study contrast with data collected previously by Schemel et al. (2002), which showed lower nitrate concentrations during inundation of the Bypass and average concentrations of approximately 50 mg/L and as high as 360 mg/L. These data appear erroneous. Other data reported by USGS (Domagalski et al., 2000) suggest that nitrite+nitrate concentrations in the Colusa Basin Drain range from 0.2 to 1.0 mg/L with a median of 0.4 mg/L. These concentrations are essentially equivalent to concentrations measured during this project.

Sinks or losses of nitrate include sequestration in local soils and plant material, and denitrification leading to volatilization of nitrogen gas. The dominant loss mechanism is likely denitrification.

Organic Carbon

Organic carbon was monitored at the level of total and dissolved concentrations. The concern with organic carbon is that more of it produces more trihalomethanes, a carcinogenic by-product of chlorination for drinking water supplies. There is no criterion except an appreciation that less is better for drinking water supplies.

Spatial Patterns

Total and dissolved organic carbon tended to be higher in the two agricultural drains, Knights Landing Ridge Cut and Willow Slough Bypass, and in the Toe Drain, while Putah and Cache Creeks had lower concentrations. The percentage of streambed sediment that was TOC was highest in Cache Creek but among the lowest in Putah Creek. This difference between agricultural runoff and major creeks is consistent with the findings by Schemel et al. (2002).

The total organic carbon was almost entirely dissolved. This contrasts the findings by Schemel et al. (2002) that approximately half of the organic carbon was in particulate form.

Temporal Patterns

There was no clear difference in wet versus dry season concentrations of total or dissolved organic carbon. These data do not corroborate the findings by Schemel et al. (2002) that DOC in the Yolo Bypass was lowest during the inundation period, and then increased in late March to values that were relatively stable for the remainder of the study.

Conceptual Model

Organic carbon appears to come from multiple sources, contributing throughout the year. The majority of the carbon is dissolved, indicating that structural control measures that settle out particulate material would be ineffective at reducing organic carbon loads. Sinks or losses of organic carbon include sequestration in local soils. Losses of total organic carbon within the Bypass are likely insignificant.

The TOC data in sediment samples do not support any correlations with mercury content or methylmercury production.

Pesticides

While entire classes of pesticides were monitored, only five were ever detected. Only the detected pesticides are assessed here:

- Organochlorine – <u>DDT</u> is classified as an organochlorine (OC) pesticide. DDT breaks down to <u>DDE</u> in the environment. This class of compounds is generally characterized as having a high tendency to partition to particles, bioaccumulative, and persistent in the environment. DDT was once widely used to control insects on agricultural crops and insects that carry diseases like malaria and typhus. Its use in the US has been banned since 1972. It may be present in soils and water from air transported globally or evaporated locally. The primary concerns with DDT in the environment are chronic toxicity to aquatic organisms and carcinogenic effects to consumers of contaminated fish. 4,4'-DDE was detected in three samples, all of which exceeded the applicable criterion. The only detected pesticide in sediment samples was 4,4'-DDE, but in Putah Creek (*not* one of the three sites where DDE was detected in the water column. DDT was not detected in any samples.

- Organophosphate – Diazinon and chlorpyrifos are organophosphate (OP) pesticides. In recent years they have been widely used insecticides in agricultural and urban areas. These pesticides are used on orchard crops during the dormant season (i.e., the wet season). Diazinon and chlorpyrifos are being phased out by a federal ban for most residential and commercial uses, although agricultural uses continue. Diazinon was never measured as exceeding its applicable criterion, while the four samples with detectable concentrations of chlorpyrifos all exceeded its applicable criterion.
- Carbamates – Diuron is a carbamate pesticide that works by inhibiting photosynthesis. It is used locally to control a wide variety of annual and perennial broadleaf and grassy weeds. It is used on non-crop areas and many agricultural crops such as fruit, alfalfa, and wheat. Diuron is moderately to highly persistent in soils and surface water. Methomyl is a carbamate pesticide used for summertime worm control on alfalfa. Although detected, concentrations of diuron and methomyl never exceeded their applicable criteria. Carbamate pesticides used in rice cultivation include predominately thiobencarb and molinate, but neither of these chemicals was monitored.

Pyrethroids are another class of pesticides that are becoming more popular as uses for the organophosphates are phased out. Pyrethroids are synthetic chemical insecticides that act in a similar manner to pyrethrins, a natural chemical derived from chrysanthemum flowers. Pyrethroids are widely used for controlling various insects, including mosquitoes. Pyrethrin is extremely toxic to fish while slightly toxic to bird species, such as mallards. They degrade rapidly and thus do not tend to persist in the environment or bioaccumulate. Pyrethroids were not monitored for this project, but are discussed within the realm of potential pesticides in the Bypass.

Spatial Patterns

Four of the five detected pesticides were detected in the Knights Landing Ridge Cut. Three of the four detected pesticides were detected in the Willow Slough Bypass, also representing agricultural runoff. 4,4'-DDE, the primary degradation product of DDT, was detected at both of these sites. Methomyl and diazinon were also detected in Cache Creek.

National Water Quality Assessment Program (NAWQA) data suggest that Colusa Basin Drain water was among the nation's most degraded sites in terms of OP insecticide concentrations (Domagalski et al., 2000). But this study's data indicate that Knights Landing Ridge Cut, which conveys Colusa Basin Drain water, rarely exceeded the chlorpyrifos criterion and never exceeded the diazinon criterion. This finding is most likely the combined result of two factors: (1) OP pesticide use in the watershed has decreased, and (2) pesticide management practices are successfully minimizing discharges of OP pesticides from rice fields.

NAWQA data also suggest that DDE concentrations in the Colusa Basin Drain were 2-100 times higher than other sample sites in the Sacramento River watershed (Domagalski et al., 2000). Although DDE was detected in the Knights Landing Ridge Cut and Willow Slough Bypass, only 3 of 12 samples had detectable levels.

Temporal Patterns

There was no seasonal peak in concentrations during or following the rice pesticide application period (spring) or rice field draining period.

Diuron was detected in April and June. Methomyl was detected in April, chlorpyrifos in June, diazinon in January, and DDE in June and August. The finding that DDE was detected while DDT was not indicates that the source of this legacy pesticide is soil residue rather than illicit uses.

Conceptual Model

The pesticides detected in west-side tributaries likely come from current, legal uses on farmland or from soil in the case of legacy pesticides such as DDE. While DDE was detected in one sediment sample, all other pesticides were below detection limits in all other sediment samples. Diuron, a carbamate pesticide used on a variety of crops, was detected more often and at more sites than any other pesticide.

Sinks or losses of pesticides include volatilization, degradation, trapping in local soil, and biouptake. The dominant loss mechanism is likely degradation for OPs and sedimentation for OCs. Carbamate pesticides could be reduced by both mechanisms at equivalent rates.

Salinity

Salinity was measured monthly in the field as electro-conductivity (EC), and in lab samples as TDS. The pattern of EC and TDS consistently indicated that the agricultural drains had relatively higher salinity while the floodwaters and creeks had relatively lower salinity.

Spatial Patterns

The agricultural drains, Knights Landing Ridge Cut and Willow Slough Bypass had the highest EC levels of all 12 sites and were the only two sites that on average exceeded the potentially applicable EC and TDS criteria. The highest average EC, at the Willow Slough Bypass, was 920 umhos/cm, while the most downstream site, the Toe Drain, averaged less than 500 umhos/cm. These readings are similar to and consistent with salinity levels measured previously by others (Domagalski and Dileanis, 2000; Schemel et al., 2002).

In-Bypass salinity increases downstream through Tule Canal, but salinity at the farthest downstream site is lower than all other contributing sites except for the floodwaters. The source of diluting water is unknown.

Based on conductivity measurements and permitted dry weather flow rates for the Cities of Woodland and Davis wastewater treatment facilities, approximately 25 million pounds of dissolved solids (i.e., TDS) are discharged *into* the Bypass during the dry season (May-November). Based on measurements of TDS and flow rate at Lisbon Weir in the Toe Drain, approximately 40 million pounds of TDS were discharged *from* the Bypass during the same period.

Temporal Patterns

Floodwaters had the lowest EC levels of all sites. Dry season EC readings were higher on average for each site than wet season readings.

Floodwaters likely flush out any salts that accumulate over time in the Bypass. There is no evidence in model simulations, soil studies, or agricultural production assessments to indicate that salts are accumulating in the Bypass over time.

Conceptual Model

Possible sources of salts to local wastewater treatment plants include:

- Water supply (deep groundwater aquifer pumping),
- Water softeners,
- Municipal wastewater treatment chemicals, and
- Indoor water use (chemicals, cleansers, food, etc.).

An assessment of salt (as chloride) sources to municipal treatment plants in the Santa Clarita Valley area (LACSD, 2002) produced the pie chart shown in Figure 15. It is assumed that contributions within the City's of Woodland and Davis would be distributed similarly.

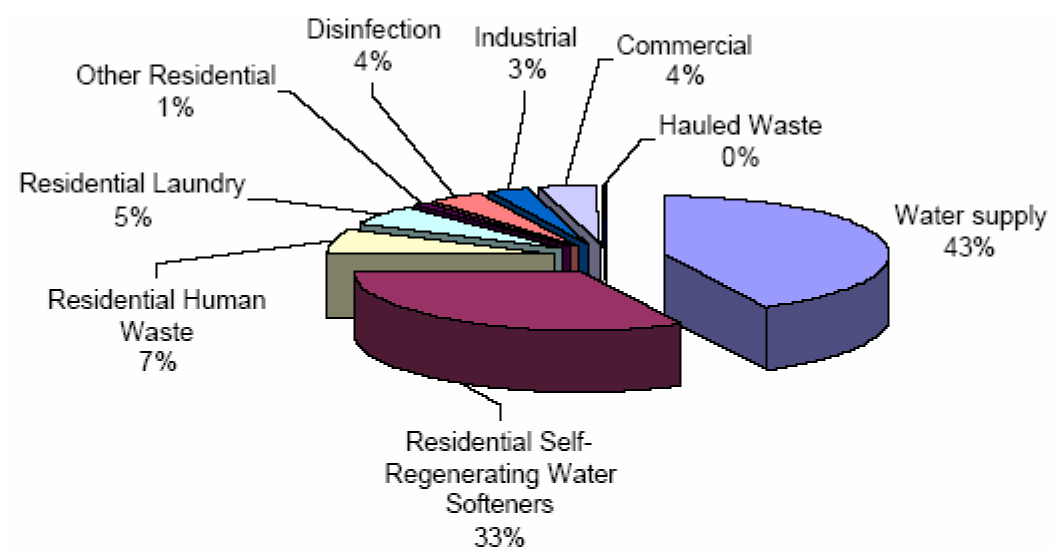


Figure 15. Breakdown of sources of chloride to municipal treatment plants in the Santa Clarita Valley area.

Possible sources of salts in rural tributaries and agricultural drains include:

- Water supply from deep groundwater aquifer pumping,
- Leaching and ex-filtration of groundwater,
- Atmospheric deposition,

- Pesticides and fertilizers, and
- Salt water intrusion.

Evapotranspiration tends to increase salinity as well, although this process is not a source of salts.

The only potential sink identified for salts is sequestration in local soil. Because of the intensive irrigation re-use of water in the Bypass, a large proportion of the salt entering the Bypass during the dry season likely accumulates temporarily in local plant material and soil. However, this loss mechanism is likely insignificant compared to the amount flushed out to the Delta during annual flood events.

Total Suspended Solids

TSS was monitored primarily to consider the potential for transport of sediment-bound POCs.

Spatial Patterns

The agricultural drains, Knights Landing Ridge Cut and Willow Slough Bypass had among the highest TSS concentrations while Putah and Cache Creeks had the lowest TSS concentrations. This finding is expected, recognizing that the Creeks both have dams and settling basins that trap large amounts of sediment. In-Bypass sites had TSS concentrations only slightly lower than the agricultural drain sites. Overall the concentrations are slightly lower than suspended particulate matter measured previously by Schemel et al. (2002).

Temporal Patterns

In-Bypass and west-side tributaries had higher TSS concentrations during the wet season, while agricultural drains had higher TSS concentrations during the dry season. In neither Cache Creek nor Willow Slough Bypass did TSS concentrations correlate with flow rate.

Conceptual Model

Dams and settling basins in the City of Davis and UC Davis campus and in the two main Creeks appear to regulate sediment loads entering the Bypass such that concentrations are not significantly higher in any season or during higher flows.

Erosion and deposition of sediment along the Bypass is not routinely measured but reportedly occurs in various areas. Other than in ditches and near Fremont Weir, sediment deposition does not appear problematic in the Bypass. Scour is observable from high spots like internal levee roads and in the northeast corner of the Bypass.

Prioritization of POCs

The POCs can be prioritized for planning purposes. The prioritization scheme employed is as follows:

- High Priority – These pollutants exceed accepted criteria often and in multiple locations or are important to stakeholders for various reasons. These highest-priority pollutants should be dealt with expeditiously with appropriate control measures or other means.

- Medium Priority – These pollutants occasionally exceeded accepted criteria. These pollutants will continue to be listed as POCs and an implementation plan will be included but will not be the focus of near-term activities.
- Low Priority – Monitoring data do not indicate that these pollutants ever exceed accepted criteria. These pollutants will no longer be classified as POCs. No implementation plan is provided for these lowest-priority pollutants.

Based on the information presented above, The POCs are prioritized as shown in Table 10. Implementation plans for high and medium priority POCs are included in the final section of this report.

Table 10. Prioritization of POCs for the Yolo Bypass Water Quality Management Plan.

POC	Priority		
	High	Medium	Low
Bacteria	X		
Total coliform			
Fecal coliform			
E. coli			
Boron	X		
Metals			
Aluminum	X		
Chromium			X
Copper			X
Lead			X
Mercury	X		
Selenium			X
Nitrate			X
Organic Carbon		X	
Total organic carbon			
Dissolved organic carbon			
Pesticides and Herbicides			
OCs (DDE and DDT)		X	
OPs (Chlorpyrifos and Diazinon)		X	
Carbamates (Diuron and Methomyl)			X
Salinity	X		
Total Suspended Solids (TSS)			X

POTENTIAL CONTROL MEASURES FOR HIGH AND MEDIUM PRIORITY POCS

Potentially feasible control measures were identified prior to deciding how to address the POCs. Potential options for addressing the high and medium priority POCs fall into three main categories:

- Implement control measures;
- Continue monitoring and undertake special studies; and
- Pursue development of a site-specific objective or a change in the designated beneficial uses through a Use Attainability Analysis.

The focus of this section is to identify and quantify to the extent practicable potential control measures to implement. Control measures are defined as structures, activities, management practices, or processes that may minimize pollutant loads to the Yolo Bypass. Best Management Practices (BMPs) are control measure activities recognized to minimize pollutant loads in the most effective, efficient manner. However, the term "best" is not meant to imply that such practices are the only effective and efficient way to minimize pollutant loads. The term "control measure" is used to represent any activity or structural device used to control the discharge of POCs to the Bypass. In general, BMPs traditionally apply to agricultural non-point sources of pollution and urban stormwater while control measures are often associated with point sources of pollution such as POTW effluent.

Control measures that could potentially be used to address at least one of the POCs are listed in Table 11. They are generally in order of upstream/source control to downstream/discharge control. Each control measure listed in this table is described in its own section, following a standard format:

- POCs addressed;
- Description;
- Benefits;
- Costs; and
- Other considerations.

Costs and benefits are quantified to the extent practicable and generally in terms of order-of-magnitude estimates. Information on past, present, and future planned implementation of these control measures is also provided, where known. This section was adapted from a technical memorandum reviewed previously by stakeholders (Appendix 7).

Table 11. Summary table of control measures and the POCs that each addresses, as described in this section.

BMP or Control Measure		POCs Addressed						
#	**Name**	**Aluminum**	**Bacteria**	**Boron**	**Mercury**	**Org. C**	**Pesti-cides**	**Salinity**
1	**Conduct General Outreach and Education**		X		X	X	X	X
2	**Reduce Local Groundwater Use**							
2a	Develop Alternative Water Supplies			X			?	X
2b	Reduce Urban Water Demand			?				?
3	**Reduce POTW Influent Loads**							
3a	Encourage Alternatives to Conventional Water Softeners							X
3b	Outreach on Proper Operation of Water Softeners							X
3c	Conduct Mercury-specific Outreach and Education				X			
3d	Enhance Industrial Pretreatment	?			?		?	?
4	**Enhance POTW Treatment**							
4a	Install Tertiary Treatment	?	X		?	?	?	
4b	Install Microfiltration – Reverse Osmosis	X		X	X			X
5	**Improve Urban Storm Water Management**							
5a	Minimize Effects of New Development		X			X	X	
5b	Outreach to Minimize Stormwater Impacts	X	X	?	X	X	X	?
6	**Improve Rural Land and Water Management**							
6a	Construct or Improve Settling Basins	X			X		X	
6b	Enhance IPM Programs						X	
6c	Enhance Irrigation Water Management						X	X
6d	Optimize Pesticide Applications						X	
6e	Restrict or Change Pesticide Use						X	
6f	Minimize Erosion and Sediment Transport to Waterways	X	X		X	X	X	
6g	Remove or Stabilize Mine Waste				X			
7	**Manage Water Resources for Water Quality Benefits**							
7a	Minimize POTW Discharges to the Bypass	X	?	X	?			X
7b	Manage Water Use in Bypass Wetlands	X	?	?	?	X	X	?
7b	Alter Inter-basin Water Transfers		?	X	?	?	?	X

"X" indicates some benefits *likely* could be realized by applying this control measure in the watershed.
"?" indicates some potential *benefits or detriments* could be realized by applying this control measure in the watershed.

Conduct General Outreach and Education

POCs addressed: bacteria, mercury, organic carbon, pesticides, salinity

Description

General outreach efforts that could be considered include: 1) post information on web sites maintained by municipalities and environmental organizations; 2) develop fact sheets for dissemination to the public; 3) utilize press releases at appropriate times (e.g., Earth Day); 4) prepare and give PowerPoint presentations at appropriate venues; and 5) enhance communication and collaboration among agencies and other authorities that manage water resources affecting the Bypass. These activities improve the public's general awareness of local water quality issues impacted by their actions. Pollutant-specific outreach is addressed separately in this memo and would overlap considerably with this control measure.

An additional outreach activity is to inform farm workers and recreational visitors in the Bypass that bacteria levels are high to discourage swimming. Outreach could be conducted by distributing informational fliers or posting notices at potential swimming areas.

Another outreach activity could be to discourage the consumption of fish high in mercury. However, although the state has data on methylmercury in small fish in the Bypass, it has no information on sizes and species consumed by people. A possible useful activity would be to collect data on species targeted by people and, if the levels are above recommended levels, post notices at popular fishing sites.

Benefits

Outreach and education provide relevant information to people regarding the condition of their environment, the impacts that such conditions may have on them, the impacts they may have on the environment, and options for how to change their practices. Outreach can be an effective means of pollutant reduction and risk reduction for humans. Education provides the foundation for outreach, while also encouraging decision-makers and the people they serve to implement additional control measures.

Focused interactions among responsible authorities improve efficiency and consistent understanding of responsibilities for protecting water quality.

Costs

Effective public outreach campaigns for municipalities the size of Davis and Woodland would cost on the order of $100,000 per year (Elzufon, 2000). Agency collaboration activities require staff time, but presumably are balanced by improved operating efficiency. Outreach to potential swimmers in the Bypass could be accomplished through fliers distributed to farm workers and notices on message boards at the Yolo Basin Wildlife Area and at other areas where Bypass waters are accessible to farm workers and to the public.

Other Considerations

While outreach and education can be fairly effective in comparison to the cost, it does not usually solve a water quality issue on its own. In addition, such campaigns take time to change the behavior of the general population. However, it remains an important element of any management plan and should not be overlooked. More focused outreach activities are described as components of other control measures.

Reduce Local Groundwater Use

Municipalities and agriculture within and around Yolo County rely on local groundwater resources as a water supply for municipal and irrigation uses. Groundwater in the area is known to contain high levels of salinity and boron. Therefore, by using groundwater as a source of water supply, municipal discharges and irrigation return flows automatically contain higher levels of such constituents. Consequently, one control measure to reduce such inputs would be to reduce the use and reliance on high salinity groundwater by developing other water sources or by reducing demand.

Improve Source Water Quality

POCs addressed: boron, salinity

Description

Typical salinity levels measured in City of Woodland wells (LWA, 2003; pers. comm. Christine Engel, City of Woodland to S. McCord, 3/5/05) are:

- Supply wells = 900-1100 umhos/cm
- POTW influent = 1650-2000 umhos/cm

Based on these data, municipal uses appear to increase salinity by 500-1000 umhos/cm. Lower hardness supply water should result in a smaller decrease in salinity as softener salts can be dosed less and soaps work better.

Recognizing that groundwater is the dominant source of high hardness and salinity in irrigation tailwater and POTW effluent, reducing the flow from that source by developing alternative water sources is a potential solution. Alternative sources are described here.

- Sacramento River – Sacramento River water[10] has an average conductivity of 140 umhos/cm.
- Deep aquifer groundwater wells that are less saline – such wells in the City of Davis produce water that has an average conductivity of 550 umhos/cm.

Installing deep aquifer wells as a means to reduce salinity in the UC Davis campus wastewater is not an option because all domestic wells serving the campus are already in the deep aquifer.

Benefits

Based on the salinity levels given above, POTW influent EC would be in the range of 700-1600 umhos/cm if Sacramento River water were part of the supply source, depending on the blend of supplies that could be provided. As a result, wastewater effluent would be considerably lower in salinity and would therefore not be of concern for agricultural or municipal uses of the effluent.

The City of Davis and UC Davis campus have already tapped into deeper wells to try and reduce the salinity of their water supply. However, the use of such wells does not solve the salinity issues for the municipal wastewater dischargers. For example, POTW influent EC would be in the range of 1100-1600 umhos/cm if deeper well water were used as a supply source, depending on the blend of supplies that could be provided.

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[10] Based on measurements at Veteran's Bridge reported in the Coordinated Monitoring Program's 2003 Annual Report, available on-line at http://www.srcsd.com/pdf/rpt-cmp-03.pdf.

Delivering better quality supply water would also benefit users by improving drinking water taste and reducing uses of soaps and water softener salts.

Costs

In order to obtain a surface water supply, the municipalities must go through the State Water Resources Control Board and obtain an appropriative right, or contract with other entities that currently have surface water rights. In either case, the Cities, UC Davis, and agricultural water suppliers would incur costs associated with this process. In addition, surface water supplies are likely to cost more per acre foot then the cost that is currently associated with groundwater pumping costs.

Installation costs for new wells tapping the deep aquifer cost on the order of $1.2 million (pers. comm., David Phillips, UC Davis, to S. McCord, 2/10/05). The cost of installing deep aquifer wells for agricultural groundwater users may not be practical.

Other Considerations

Besides a potential cost increase, the ability to successfully obtain rights to a surface water source for water supply is not guaranteed. As the population in California continues to grow, there are additional demands on California's surface water supplies. As a result, obtaining surface water rights is a competitive process that offers no guarantees. The Cities of Davis and Woodland have had applications for Sacramento River water rights pending before the State Board for over five years.

Another consideration is the actual need for municipalities to obtain alternative sources of water in order to reduce salinity in the effluent. Currently, the primary beneficial uses that are driving the issue are municipal and agricultural uses. The DHS secondary drinking water standard for municipal uses is a minimum of 900 umhos/cm[11]. The most conservative number currently used for agriculture is 700 umhos/cm. The 900 umhos/cm for municipal uses applies to Putah Creek and therefore the University of California, Davis' discharged effluent. It is based on the secondary maximum contaminant level (MCL), which is a consumer acceptance taste and odor standard and not a public health level. DHS commonly approves drinking water supplies that exceed this level. The Bypass is not designated as having a beneficial use of municipal drinking water supply.

The 700 umhos/cm level for agriculture is subject to even further questions of applicability in this area. The standard comes from a United Nations study that recommends water quality goals and guidelines. The 700 umhos/cm is the most conservative recommended standard for the most salt sensitive crops in all climates throughout the world, including arid and desert regions. It does not account for natural conditions, actual crops grown or rainfall. As a result, studies are currently underway to determine what may be an appropriate standard for the Yolo Bypass area considering all the necessary factors. The studies are being conducted by researchers at the University of California, Davis. In addition to these studies, the local agricultural community is not convinced that 700 umhos/cm is necessary for the crops grown in and near the Bypass. The agricultural community appears to be more concerned with potentially losing the irrigation water created from these discharges than with receiving irrigation water with a slightly higher level of salinity. Average salinity in the Bypass is already below 700 umhos/cm.

Residential development in Lake County may develop surface water storage. These reservoirs could provide some additional relatively low salinity water to Cache Creek during the dry season.

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[11] The secondary drinking water standards for EC can be found in Table 64449-B of Title 22, Div 4, Chap 15, Article 16 and for Specific Conductance, in micromhos: 900 (Recommended), 1,600 (Upper Limit), 2,200 (Short Term).

Reduce Urban Water Demand

POCs addressed: boron, salinity

Description

Groundwater pumping for urban areas could be reduced by reducing water demand directly or by expanding local water reuse to effectively reduce demand for new water. Potentially effective tools include outreach/education, installation of water meters and water use fees based on use rates, installation of improved water use technologies, and enforcement of landscape water use standards.

Benefits

Salt and boron loads introduced from groundwater aquifers could be reduced by reducing groundwater use and subsequent discharge.

Costs

Minimal costs to municipalities would be incurred for conducting outreach and education to reduce water demand.

Residents can purchase improved technologies for plumbing fixtures, washing machines, irrigation systems, and water heaters. Industrial and commercial units can install low-flow toilets and high efficiency cooling towers. Costs associated with designing, constructing and operating local water reuse systems are undetermined.

Increased energy efficiency tends to balance costs of irrigation controller systems and indoor technologies (DWR, 1998). Similarly, WWTP treatment costs could be slightly reduced for the lower influent flows.

Other Considerations

The net result of reducing water use would be to reduce pollutant *loads* to local waterways. However, the salt *concentration* in POTW influent would be slightly higher as the slightly lower load of salinity added in the service area would be concentrated in proportionally less influent water. Consequently, the advantage of increased water efficiency may not improve water quality. In addition, the loss of effluent may negatively impact the agricultural community that relies upon the effluent discharge for irrigation purposes. Many of the available water conservation measures have already been promoted through rebate programs and are unlikely to result in large incremental reductions in water use.

Local agencies are required by the 1990 Water Conservation in Landscaping Act to enforce ordinances intended to promote water-efficient designs. The Act's requirements apply to landscapes greater than 2,500 square feet in area. Water used for landscape irrigation is an indirect and probably a miniscule load to the nearest water body.

DWR (2000) deferred implementing regional scale urban water conservation options, reasoning that no significant depletion reductions were attainable.

Reduce POTW Influent Loads

POTW influent loads of some POCs can be reduced by focusing on the major sources of those POCs. This section describes several control measures that could be implemented within POTW service areas to reduce influent POC loads. These measures could be expected to reduce POTW effluent loads.

Encourage Alternatives to Conventional Water Softeners

POCs addressed: salinity

Description

The typical self-regenerating water softener operates by removing the ions contributing to hardness with an ion exchange resin column. Over time, the column becomes saturated with the hardness ions, and it becomes necessary to replenish the sodium ions via regeneration. By passing a strong brine solution (about 3 pounds of salt per gallon, equivalent to approximately 360,000 mg/L) through the bed, the hardness ions are overwhelmed by the strength of the sodium ions and are driven off the bed. At the end of the process, the waste brine is discharged to the sanitary sewer. The waste brine is a source of salts discharged to POTWs.

Salts can be reduced in POTW influent by implementing tighter controls for water softeners, and perhaps new pre-treatment technology for some industrial equipment (e.g., boiler feed water). Alternatives to self-generating water softeners include portable tank exchange services, magnetic / electronic / catalytic water conditioners, reverse osmosis, carbon filtration, and distillation. Similar alternatives to conventional softeners could also be applied at wellheads rather than at individual buildings.

Benefits

UCD has estimated that a 3-10% reduction in POTW influent salinity may be possible by incorporating advanced technology for boiler feed water and other major water uses (pers. comm., D. Phillips).

It is estimated that the Cities of Davis and Woodland combined may be able to reduce total salt loads to the Bypass by approximately 5,000 pounds per day if 40% of the households with self-generating water softeners would replace such systems. This is assuming that there are 40,000 households in Davis and Woodland combined and that 20% of households have self-regenerating water softeners.

Costs

Rebates, credits and buy-back programs can be used to promote alternatives to conventional water softeners. Assuming 40,000 households in Davis and Woodland combined, 20% of households have self-regenerating water softeners, 40% of those households would decide to participate in the program, and $800 for providing an alternative softener system, total costs for implementing a water softener replacement program would be approximately $2.5 million if it is assumed that a $800 rebate is given to 40% of the households with self-regenerating water softeners. Costs to homeowners would be on the order of $3000 per whole-house unit without rebate.

Other Considerations

Brine produced by softening all potable water and disposal of brine from wellheads distributed throughout the municipalities would be problematic.

Municipalities can ban water softeners for new development only under certain limited circumstances. Municipalities cannot legally ban existing water softeners, but they may be able to provide incentives for alternatives. However, alternatives can be expensive to purchase and maintain. Any brine, precipitate or filters must be disposed rather than discharged back to the sanitary sewer.

Outreach on Proper Operation of Water Softeners

POCs addressed: salinity

Description

For wastewater dischargers into the Yolo Bypass, salinity issues are of the greatest concern. A large source of salinity in wastewater comes from self-generating water softeners. Outreach and education to members of the public regarding the impact of inefficient water softeners and instructions on efficient use could help to reduce salt loads.

Benefits

If only 40% of the households participated in a program to increase water softener efficiency (assuming 40,000 households in Davis and Woodland combined and 20% of the households having self-regenerating water softeners) each of those participating systems could be made 10% more efficient, total salt loads to the Bypass could be reduced by approximately 500 pounds per day.

Costs

Effective public outreach campaigns for municipalities the size of Davis and Woodland would cost on the order of $100,000 per year (Elzufon, 2000). Such a campaign could incorporate multiple elements besides water softeners.

Other Considerations

None identified.

Conduct Mercury-specific Outreach and Education

POCs addressed: mercury

Description

Mercury's unique chemical characteristics, sources and environmental impacts may require special control measures. Potential control strategies identified for mercury are listed in Table 12.

Table 12. Potential Mercury Source Control Strategies.

Potential Source	Control Strategy
Dentists	Business outreach with BMPs; regulate
Household products (thermometers, contact lens solution, fluorescent light bulbs)	Outreach to pharmacies; public thermometer collection program; fluorescent light bulb exchange program
Hospitals; laboratories	Outreach; sewer line cleaning
Laundry	Promote graywater systems

Benefits

Both POTW effluent and urban stormwater would benefit from these outreach activities. It is difficult to quantify the potential benefit that municipalities in the Bypass may obtain by implementing the control strategies above. However, examples from other POTWs may provide a useful illustration of potential benefits.

First, the City of Palo Alto quantified its annual influent loading of mercury by source (Elzufon, 2000). These potentially controllable sources represented approximately 30% of the total influent mercury load. Assuming that these loads could be reduced by approximately 50%, the potential total influent load reduction by implementing all of these control strategies would be on the order of 15%. The resulting reduction in effluent load would be 0-15%. The low end of this range is in recognition that a reduction in influent mercury load does not necessarily translate into reduction in effluent load.

Second, the Sacramento Regional County Sanitation District (SRCSD) has implemented an effective mercury reduction program that could be mimicked in the Yolo Bypass watershed[12]. SRCSD's residential mercury outreach and collection efforts have resulted in the removal of an estimated 18.5 pounds of elemental mercury and approximately 192 pounds of mercury and mercury-containing products over the past two years. Scaling these values by the proportional populations (~100,000 in the Davis and Woodland communities versus ~1 million in the Sacramento service area), local outreach efforts would result in approximately 2 pounds of elemental mercury being collected. Considering that conventional wastewater treatment facilities remove on the order of 90% of influent mercury, the load reduction to the Bypass would be on the order of 0.2 pounds.

Costs

Costs to POTWs for implementing these control strategies are primarily associated with staff time needed for interact with businesses such as dentists, pharmacies and hospitals that may not be regulated currently. Public outreach activities would require educational materials and staff resources as well. There may also be some costs associated with monitoring the collection system to better determine the amount of mercury that is entering the POTW from the various areas of the collection system.

Other Considerations

The City of Woodland is currently surveying local dentists to determine what mercury reduction measures are used currently.

As described later, the cities of Davis and Woodland have been asked to characterize the methylmercury in their wastewater effluents. If elevated, the cities might be required to implement programs to reduce the methylmercury in the effluent and that might provide impetus for outreach and education.

Enhance Industrial Pretreatment

POCs addressed: aluminum, mercury, pesticides, salinity

[12] See the "Be Mercury Free" website at http://www.bemercuryfree.net/index.html.

Description

Pretreatment programs for industries such as vehicle service facilities, printers, and commercial car washes can reduce metals loads to sewers. Food processing industries often discharge high salt loads that could be reduced.

Benefits

Load reductions of 30-99% for many heavy metals (e.g., copper, mercury, lead, silver, zinc) can be achieved by such facilities. The resulting percent reduction in POTW influent depends on the relative contribution of industries.

Costs

Effective pretreatment programs for municipalities the size of Davis and Woodland cost on the order of $50,000 per year (Elzufon, 2000).

Other Considerations

The City of Davis, in particular, is a residential community with a small industrial base. The industrial pretreatment programs for both the Cities of Woodland and Davis prioritize BOD, solids, fats, oil, and grease for pretreatment. Local limits for City of Woodland's four Significant Industrial Users include the pollutants of concern mercury and DDT. The City of Davis and UC Davis campus do not have local limits.

Industries that tend to produce high-salinity wastewater include, for example, textiles, food processors, and petroleum refineries. None of these or similar industries exist on a large scale in the watershed. Thus, industrial pretreatment local limits for salts would have negligible benefits on salinity in POTW effluent.

As described later, the cities of Davis and Woodland have been asked to characterize the methylmercury in their wastewater effluents. If elevated, the cities might be required to implement programs to reduce the methylmercury in the effluent and that might provide impetus for additional industrial pretreatment control measures.

Enhance POTW Treatment

Three advanced wastewater treatment technologies are discussed in this section:

- Tertiary treatment;
- Carbon adsorption; and
- Microfiltration – reverse osmosis.

Other technologies such as nitrification-denitrification and ultraviolet disinfection would not address high or medium priority POCs.

Install Tertiary Treatment

POCs addressed: aluminum, bacteria, mercury, organic carbon, pesticides

Description

Primary treatment of wastewater reduces oils, grease, fats, sand, grit, and coarse (settleable) solids. Secondary treatment of wastewater means biological oxidation to reduce further BOD and suspended solids concentrations. Tertiary treatment of wastewater provides additional treatment for more specific water quality benefits. Common tertiary treatment processes include filtration, and polishing wetlands.

Benefits

Organic pesticides and inorganic compounds such as nitrogen, sulfides, and heavy metals are generally reduced to some degree by tertiary treatment.

Costs

The City of Woodland estimated that total 20-year life-cycle costs to upgrade to tertiary treatment would be approximately $20 million (ECO:LOGIC Engineering, 2003).

The UC Davis campus wastewater treatment facility operates a tertiary treatment facility. The filters cost approximately $1.8 million for the current 2.5 MGD design flow rate (pers. comm., David Phillips, UC Davis, to S. McCord, 2/10/05). Operation and maintenance costs will result in similar life-cycle costs as for the City of Woodland.

Other Considerations

Because tertiary treatment processes tend to target specific pollutants, (e.g., BOD, TSS, bacteria) systems cannot be expected to reduce effluent concentrations of other pollutants.

Install Microfiltration – Reverse Osmosis

POCs addressed: aluminum, boron, mercury, salinity

Description

Microfiltration following tertiary treatment produces effluent suitable as a feed source for reverse osmosis. Reverse osmosis (RO) is a water treatment technology that utilizes membrane filters to remove dissolved substances. This control measure only addresses constituents that were not removed by tertiary treatment. Water is separated from dissolved salts in solution by filtering through a semi-permeable membrane at a pressure greater than the osmotic pressure caused by the dissolved salts in the wastewater.

Benefits

High-salinity effluent can be treated to reduce salinity as well as other particulate and dissolved compounds. An RO system could be operated at moderate performance levels to simply improve conditions, or at maximum efficiency to produce potable water.

Costs

The major costs associated with RO systems include construction, operation, and brine disposal. Approximate costs for Florida (United States Navy, 2005) are:

- Construction ($mil/MGD capacity): 1.4-2.1
- Operation and maintenance ($/million gallons of production): 1,060-1,550

Total costs approximated for a 10 MGD facility with a 20-year life cycle and not discounted would be $5-7 million per year. A deep well in which to inject the brine would cost on the order of $1 million.

The City of Woodland estimated that total 20-year life-cycle costs to treat approximately half of its wastewater through RO filters and evaporate the brine would be approximately $110 million (ECO:LOGIC Engineering, 2003).

Other Considerations

The major constraints to installing and operating RO systems include:

- Disposal of a continuous waste stream of RO brine (the process water that does not pass through the filters) is especially problematic in inland areas. Brine could be injected into deep wells. Potential impacts on groundwater aquifers are unknown. Piping or otherwise transporting brine to the ocean is not perceived to be a realistic option;
- The high capital investment should be preceded by information to show that high salinity effluent is problematic and caused by wastewater effluent;
- Effluent discharges would be reduced by approximately 20%, decreasing water supply available to current water users in the Bypass; and
- Operation of RO systems requires higher energy for pressuring the process water.

Because the major water supplies for the Cities of Davis and Woodland are groundwater, wells are decentralized. A separate piping system to remove and treat the brine from each of the dozens of wells would require an entirely new piping system. Brine injection wells would each cost on the order of $1 million to construct and operate.

Improve Urban Storm Water Management

Water quality studies have shown impacts on receiving water caused by stormwater runoff from impervious surfaces. Pollutants associated with residential, commercial and industrial activities in a watershed include sediment, fertilizers, pesticides, other chemicals, paints, waste oil, other vehicle fluids, petroleum hydrocarbons, heavy metals, and coliform from human and animal wastes. Stormwater runoff that comes in contact with these pollutants are transported quickly and efficiently to and through the stormwater sewer system and discharged directly to receiving waters. In addition, stormwater runoff rates and quantity may significantly increase as a result of impervious surfaces cause by new development.

Stormwater discharges are regulated in California by NPDES permits. Separate permit programs relevant to the local Yolo Bypass watershed are described here.

- The Cities of Davis, Woodland, and West Sacramento, the County of Yolo and the UC Davis campus are regulated under Phase II of the NPDES General Permit for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems. Their stormwater management programs will be fully implemented by 2008.
- Construction sites disturbing greater than 1 acre of land are required to comply with the statewide NPDES General Permit for Discharges of Storm Water Runoff Associated with Construction Activity.
- Qualifying industrial facilities are required to comply with the statewide NPDES Industrial Storm Water General Permit. The State Board web site[13] indicates that two facilities in Davis, 6 on the UC

[13] Site accessed on January 19, 2004 at http://swrcbnt3.swrcb.ca.gov/stormwater/search/IndSearch.asp.

Davis campus, 28 in Woodland, and 3 in Winters actively participate in the industrial stormwater permit program.

Permittees regulated by these stormwater programs are required to reduce pollutant loads in their discharges to the maximum extent practicable, and eventually to the point that water quality objectives are achieved in the receiving waters. Specific activities expected to provide the greatest water quality benefits to the Bypass are described in this section.

Costs for municipal stormwater programs are difficult to distinguish from normal practices. A recent survey by the California Stormwater Quality Association found current costs ranging from $18 to $48 per household per year (pers. comm., Brian Currier, CSUS, to S. McCord, 3/9/05). Descriptions of costs associated with specific program elements described in this section are provided only for initial guidance.

Minimize Effects of New Development

POCs addressed: bacteria, organic carbon, pesticides

Description

The Small MS4 General Permit requires municipalities to develop, implement and enforce a program for stormwater runoff from new development and redevelopment projects that result in land disturbance of one acre or more to prevent and minimize water quality impacts. The program must include a plan to implement site-appropriate and cost-effective treatment and source BMPs and ensure long-term operation and maintenance of such BMPs. The Small MS4 General Permit requires the City and UC Davis to adopt a set of design standards for certain development categories.

Benefits

Impacts to water quality and the physical and biological characteristics of an aquatic habitat caused by new development can be minimized through implementing post-construction stormwater BMPs. BMP handbooks such as those available from the California Stormwater Quality Association[14] provide some measure of removal efficiencies for various BMPs. Removal efficiencies depend greatly on site-specific conditions.

Costs

Costs for developers to incorporate stormwater BMPs are difficult to distinguish from normal practices. Revising design standards, training staff, revising municipal code, and inspecting and maintaining facilities increase costs for municipalities. Additional land requirements for structural BMPs require more land. A recent survey by the California Stormwater Quality Association may have benchmark costs available soon.

Other Considerations

None identified.

Outreach to Minimize Stormwater Impacts

POCs addressed: aluminum, bacteria, boron, mercury, organic carbon, pesticides, salinity

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[14] Available on-line at http://www.cabmphandbooks.org/.

Description

Outreach in urban areas is required for permitted municipal stormwater management programs. Municipal stormwater outreach activities that could be promoted and the POCs that they address are identified in Table 13.

Table 13. Public outreach activities to address POCs.

Activity	POCs Addressed
Promote use of “doggy bags”	Bacteria
Announce bulk waste collection dates	Organic carbon
Announce hazardous waste collection events	Metals, pesticides
Conduct general stormwater awareness campaigns	All
Efficient operation of lawn irrigation systems	Boron, pesticides, salinity
Promote IPM programs and appropriate residential pesticide applications	Pesticides
Provide containerized green waste pick-up	Organic carbon

Benefits

The benefits of stormwater-related outreach are difficult to quantify because they depending on several factors such as current level of awareness, the design and timing of the campaign, and the imprecise relationship between the polluting activities and water quality impacts.

Several of the activities described are already practiced in the Cities of Davis and Woodland, so the additional benefit derived from increased awareness are uncertain.

Costs

Effective public outreach campaigns for municipalities the size of Davis and Woodland would cost on the order of $100,000 per year (Elzufon, 2000).

Other Considerations

Green waste containers would be most useful in the City of Woodland, and such a program is being implemented in the new portions of the City. The remainder of the City will be phased into the program. Discharges from the City of Davis are largely captured in stormwater detention ponds, in which organic carbon is not identified as a pollutant of concern.

Improve Rural Land and Water Management

Rural land management focuses on agriculture but also includes other non-point source rural areas.

For agriculture, control measures typically take the form of management practices for crop cultivation, irrigation and pesticide applications. While the Regional Board can not require specific BMPs, they can require that agricultural and other nonpoint source dischargers implement BMPs if necessary to meet water quality standards. Up until recently, the Regional Board had allowed agricultural dischargers to operate under a waiver of the requirement to file a report of waste discharge. Revisions to the California Water Code forced the Regional Board to rescind the old waiver and adopt a new one that complied with the amended provisions. The new waiver as adopted by the Regional Board requires agricultural dischargers to monitor to assess compliance, implement BMPs to address compliance issues, and eventually to comply with water quality standards. It allows compliance with the waiver provisions through individual or group development of monitoring programs, and if necessary with water quality management plans. It is anticipated that water quality management plans developed in conjunction with the waiver will identify various management practices that are designed to address the pollutant (or pollutants) that is causing a violation of an applicable water quality standard. The development of water quality management plans that are specific to agriculture in the area should be considered to be a control measure. While it is not feasible to identify all of the potential management practices because of the variability in agriculture in and near the Yolo Bypass, several common control measures are identified and discussed here.

Erosion from disturbed land and even open space contribute sediments and their associated water quality impacts. Some control measures in this section apply to non-agricultural lands.

Construct or Improve Settling Basins

POCs addressed: aluminum, mercury, pesticides

Description

Settling basins are essentially a specialized type of treatment wetland. The removal mechanism is simple settling of sediment and other particulate materials. Such material would contain a large proportion of the suspended load of weakly soluble metals and pesticides. Additional opportunities – or lack thereof – for installing new basins or optimizing the sediment removal efficiency of existing basins are as follows:

- The Cache Creek Settling Basin's sediment removal efficiency could be increased by raising the weir height or at least maintained by regularly excavating accumulated sediment.
- The 100-acre UC Davis Arboretum Waterway ("Arboretum") serves as a settling basin for campus runoff. All stormwater runoff from the central campus is routed into the Arboretum. Water collected in the channel largely infiltrates into the local aquifer. During a storm event, water from the Arboretum spills over a weir at the west end and large pumps send the water via pipeline into the South Fork of Putah Creek. Water in this basin could be pumped to and treated at the campus wastewater treatment facility during off-peak periods.

Because Lake Berryessa and Lake Solano trap the vast majority of sediment from the Putah Creek watershed, a settling basin near the mouth of Putah Creek would be redundant and ineffective. Approximately two-thirds of land within the City of Davis drains into retention ponds. The ponds are managed primarily to control floodwaters and maximize removal of particulates before discharging to agricultural drains. Wildlife and vegetation in these ponds are regularly monitored. Excavation of sediments within the Bypass is not necessary because sediment does not appear to be accumulating.

Benefits

Maintaining the Cache Creek Settling Basin at approximately maximum efficiency would remove, on average, an estimated additional 50 pounds per year of total mercury from entering the Bypass, compared to not maintaining the Basin. Potential additional load reductions for pesticides and other metals have not been quantified.

Water quality benefits to Putah Creek and the Delta from treating Arboretum water in the UC Davis campus wastewater treatment facility would be negligible. The primary benefits would be improved water quality in the Arboretum and the potential for local water reuse.

Costs

The lowest-cost alternative is to maintain the existing Cache Creek Settling Basin. Maintenance costs are estimated to be as high as $15 million[15], but depend greatly on feasible soil disposal and reuse options.

Planning, design, and construction of the project to process water from the Arboretum Waterway through the campus wastewater treatment facility will cost approximately $350,000.

Other Considerations

The State of California, acting through DWR, is responsible for maintaining the Cache Creek Settling Basin. The Delta mercury TMDL being developed in 2005 could require maintenance of the basin as a component of the implementation strategy. Local stakeholders could contribute to that activity by lobbying the legislature, sending letters in support of DWR conducting these activities, or helping to secure funding through grants.

An additional study noted later in the management plan calls for measuring sediment accumulation rates in various regions of the Bypass. The results of such a study may identify sediment hot spots on which future erosion control could be focused.

Also noted later in the management plan is that UC Davis facilities engineers are currently planning a project to reroute treated water from the Campus Wastewater Treatment Plant through the Arboretum Waterway. The purpose of the project is to provide a source of fresh water during dry weather to the Arboretum, but a potential consequence is changes in pollutant loads to Putah Creek.

Enhance IPM Programs

POCs addressed: pesticides

Description

Integrated pest management (IPM) is "an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties. Pesticides are used only after monitoring indicates they are needed according to established guidelines, and treatments are made with the goal of removing only the target organism. Pest control materials are selected and applied in a manner that minimizes risks to human health, beneficial and non-target organisms, and the environment."[16] To the

[15] Present-worth cost assuming a 30-year project life cycle, assuming the soil is disposed at the Yolo County landfill.

[16] Taken from UC Davis, Division of Agriculture and Natural Resources website, www.ipm.ucdavis.edu/IPMPROJECT.

extent that IPM programs decrease the use of broad spectrum pesticides, it can be an effective control measure for some pesticides that have been identified as a pollutant of concern.

Benefits

IPM targets the pests of concern and tries to avoid using broad spectrum pesticides or overuse of pesticides.

Costs

Costs of implementing an IPM program have not been documented, or were not found through broad research efforts. However, it can be generally assumed that IPM programs may reduce some yields, or increase the cost of crop protection materials since they are more targeted. IPM programs can also be management intensive, requiring labor for monitoring, though this can offset the costs of applying pesticides.

Other Considerations

IPM may not be appropriate in all circumstances. Occasionally there are wide spread pest infestations that can not be controlled through the use of IPM.

Enhance Irrigation Water Management

POCs addressed: pesticides, salinity

Description

Irrigation water can be managed differently to potentially reduce salinity and pesticide concentrations in tailwater. Recycling water is an efficient process that reuses local water supplies. Adoption of new irrigation technology to reduce applied water would most likely result in a reduction of deep percolation, tailwater runoff, evapotranspiration (ET), or leaching effects. Reductions of deep percolation and tailwater runoff can be achieved by improving irrigation water application and management. ET can be reduced by minimizing irrigating with minimal loss in productivity.

Benefits

More efficient water use reduces water pumping costs and transaction costs.

Longer holding times would reduce concentrations of degradable pesticides but increase salinity concentrations through evapotranspiration. Shorter holding times would have the opposite effect.

Costs

Importing additional water to irrigate fields would cost more to deliver. Within the Bypass, the typical scenario would be west-side farms needing to pump from the east-side Tule Canal or Toe Drain.

Other Considerations

A reduction in irrigation water may further concentrate salt levels in the soil causing greater damage to crops than using more, high salinity irrigation water. When water is high in salinity, one management practice to maintain crop yields is to increase the amount of water used for irrigation in order to ensure that any accumulated salt is leached from the root zone. Leaching could result in less productive soil and consequently reducing water use efficiency.

Optimize Pesticide Applications

POCs addressed: pesticides

Description

Application practices could be optimized to minimize pesticide loads to water by using any or a combination of several methods:

- Use new sprayer technologies (e.g., microsprinklers and Smart Sprayer™);
- Calibrate sprayer equipment more frequently;
- Use unidirectional spray equipment on the outer rows to spray only in toward the crops;
- Schedule irrigation to minimize impacts of irrigation return flows on receiving waters (e.g., do not spray when rain is in the near-term forecast);
- Use drift retardants;
- Target pesticide applications only to areas with infestations; and
- Improve mixing/loading procedures.

In summary, a wide variety of options are available to farmers in response to efforts to reduce runoff of pesticides that are potentially harmful to water quality. Many of these practices are already required by the pesticide label instructions and are considered legal restrictions on the use of the pesticide. Failure to follow pesticide label instructions is punishable in law and is enforced by the County Agricultural Commissioner. Management practices not controlled by pesticide label instructions may vary from grower to grower. However, such practices should be chosen in a manner to minimize the off-site movement of pesticides.

Benefits

Implementing improved pesticide application practices would result in more uniform applications at the most efficient rate. Reduced pesticide application rates would save money and result in less loss to waterways. Pesticide loads to local waterways would decrease by implementing this control measure. Depending on tree size and spacing, total pesticide applied per acre of orchard can be reduced by 10% to 80% (greatest reductions on trees 1-5 years old) compared to conventional sprayers by using technologies such as Smart Sprayer™.

Costs

Additional time and expense would be needed to install upgraded equipment and implement improved practices. No cost figures have been generated. Potential reductions in crop yields caused by reduced pesticide use have not been quantified.

Other Considerations

None noted.

Restrict or Change Pesticide Use

POCs addressed: pesticides

Description

One control measure that is often raised when addressing the issue of pesticides is further restricting (or banning) the use of a specific pesticide. This control measure is currently applied to urban uses of the organophosphate pesticides chlorpyrifos and diazinon.

One alternative to water-soluble organophosphate- and carbamate-based pesticides in fields that drain directly into waterways is pyrethroid-based pesticides. These tend to be less water-soluble, resulting in lower concentrations in irrigation tailwater (Freeman Long et al., 2002). However, there are concerns regarding the sediment toxicity of pyrethroids. If adsorbed to eroded sediments, control measures such as buffer strips or fescue in drains would minimize off-site transport.

An alternative to diuron-based herbicides is Roundup. A Roundup-ready alfalfa is coming to market in 2005. Paraquat, containing gramaxone as its active ingredient, is a contact herbicide rather than a pre-emergent herbicide applied to prevent seed germination. This type of chemical and its application tends to reduce losses to local waterways. Alternatives to methomyl are indoxycarb and glyphosate, which appear to have lower toxicity to aquatic life (pers. comm., Rachel Long, UCD Cooperative Extension, to S. McCord, 2/1/05).

Benefits

In most cases, the elimination of use should eliminate the pesticide of concern from the Bypass.

Costs

While there may be little cost to actually implement a restriction, there will be indirect costs that result from the pesticides elimination. For example, crop yields may decrease due to an increase in pests and disease; the use of alternative pesticides may be more costly for growers; and the research and development costs for replacement products are high.

Other Considerations

In California, the governmental agency with sole jurisdiction to implement such a control measure is the California Department of Pesticide Regulation. Local governmental entities and the Regional Boards do not have the legal authority to restrict the use of pesticides. However, while the Regional Boards do not have authority to restrict use of pesticides, they can restrict the discharge of those pesticides into waters of the state. Such is the case for rice herbicides where there is a prohibition of discharge unless the discharger is following specific practices contained in a management plan approved by the Regional Board. The Rice Commission develops a management plan annually[17] and submits it to the Regional Board for approval. The latest approval occurred on 18 March 2005.

The elimination of some pesticides may result in the increased application of more environmentally harmful pesticides. For example, the organophosphate pesticides (chlorpyrifos and diazinon) are considered to be broad spectrum pesticides that dissipate fairly quickly in water. As the use of these crop protection chemicals becomes more restrictive, growers are turning to alternative pesticides. In some cases, the alternatives are pyrethroids for which little information is available. The pyrethroids do not usually impact water column concentrations but may be more prevalent in the soil since these compounds bond very tightly to soil. Consequently, the pyrethroids may exist in the environment much longer then other

[17] They recently took over responsibility for this annual plan. Previously the plan was developed by DPR.

pesticides. There is little information available as to the bioavailability of pyrethroids once they adsorb to sediment.

In addition, the elimination of use does not automatically mean that the pesticide will disappear from the environment. There are several pesticides that are creating concern even though they have been banned for a number of decades (e.g., DDT).

Minimize Erosion and Sediment Transport to Waterways

POCs addressed: aluminum, bacteria, mercury, organic carbon, pesticides

Description

Three control measures that minimize erosion and sediment transport from agricultural lands are commonly promoted locally, as described below[18].

- Double-section design tailwater ponds are designed such that silt-laden irrigation tailwater and storm runoff enters the first pond (narrow trench design) which functions as a sediment trap. Captured silt is easily reincorporated into the field each fall. Nutrient-laden water exits this sediment pond via drop pipe inlet to the second, a recharge/return pond. Nutrients can be removed from tailwater by aquatic and shore plants before release into lower fields, drainage canals, or natural sloughs.
- A grassed waterway/vegetated filter system is a natural or constructed vegetated channel that is shaped and graded to carry surface water at a non-erosive velocity to a stable outlet that spreads the flow of water before it enters a vegetated filter. They can be constructed where water concentrates and gully erosion is a problem.
- A riparian forest buffer is an area of trees and shrubs located adjacent to water bodies. These areas have year-around and seasonal water available. They minimize streambank erosion, provide a wind buffer to adjacent properties, and they provide wildlife habitat.
- Inject polyacrylamide (PAM) into irrigation water to reduce off-site transport of sediment.

Erosion control could be improved for farmland throughout the watershed. For the Willow Slough watershed, a total of 2,440 acres of actively farmed cropland could be converted to tailwater ponds, riparian corridors, or large perennial wetlands (Jones and Stokes, 1996). These low-lying areas represent approximately 3.5% of the active cropland in the watershed.

The major source of mercury to the Bypass is mercury-laden sediments. A large but poorly quantified portion of this sediment is eroded native soil, while more contaminated soils emanate from historical mining areas. Erosion from lands managed by the US Bureau of Land Management will be reduced through appropriate restrictions on livestock grazing, surface mining, and off-road vehicle use (USBLM, 2004).

[18] These and other control measures are described in the NRCS web site at http://www.ca.nrcs.usda.gov/programs/buffer.html. These specific measures were suggested by Arturo Carvajal, USDA/NRCS Water Management Specialist Engineer.

Benefits

A Pilot Program funded by CALFED and conducted by Yolo County RCD found that newly dug traps removed 98% of incoming sediment in the first irrigation (which caused most soil erosion). The percent of sediment captured during the growing season in tailwater ponds studied ranged between 11 and 97%. In the one tailwater pond built in combination with a sediment trap, combined sediment capture was consistently higher, ranging between 46 and 99% (pers. comm., A. Carvajal to S. McCord, 1/24/05). The types and relative proportions of benefits for a given pond depend on location, design, and duration of impoundment.

In tailwater ditches, portable canvas dams slow runoff and collect sediments that may extend the utility life of the sediment traps, which need to be excavated to entrain new sediments. Sediment traps that are properly maintained and built in combination with a tailwater pond sediment collection become more effective and the life of the pond is increased.

Sediment traps and filters also tend to remove bacteria through the processes of filtration and degradation. Removal rates of 95% for total coliform are common[19].

Costs

Trap installations cost approximately $600 to $1,000, including cost of flashboard risers, culverts and excavation. Pond construction cost depends on pond size and type of return system (if included). The range of costs found in the Yolo County area for ponds with capacities between 1.5 and 4 acre-feet is $4,000 to $12,000 for pond and inlet/outlet structures. Addition of native vegetation on the area around the pond would add an additional $1,000 to $3,000 for material, labor, and irrigation system (pers. comm., A. Carvajal to S. McCord, 1/24/05). Filter strips and riparian buffers would cost on the order of $500 per acre per year to construct and maintain[20].

Assuming local farmland has a value of $250 per acre per year[21], the cost associated with converting 2,440 acres of productive agricultural land in the Willow Slough watershed to use as a control measure would be on the order of $610,000 per year. In terms of total land area in that watershed, the cost would be $9/acre.

Other Considerations

While tailwater recovery ponds and other sediment impoundments can work effectively to minimize pollutants entering the waterways through sedimentation and erosion, many growers are concerned about the loss of productive agricultural land and potential liability associated with the creation of additional wildlife habitat. Once habitat has been created on agricultural land, it becomes difficult to remove the habitat due to other environmental regulations and laws such as the state and federal Endangered Species Acts, state streambed alteration laws, and Corps of Engineer regulations governing wetlands. Growers and their neighbors are concerned that such control measures may attract endangered species to their property, therefore creating the potential liability for taking the species during the course of normal, cultural practices. Growers are also concerned that once created, growers lose flexibility to alter cropping practices and patterns because now the habitat may be considered a water of the U.S. or State and therefore require

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[19] Referenced on-line at http://www.wsi.nrcs.usda.gov/products/waterborn-pathogens.html.

[20] Cost estimate is adjusted from 1995 to 2005 costs, and adapted from NRCS (1995).

[21] Rental value estimate for South Sutter, Western Placer, Northern Sacramento, and Yolo Counties provided by the California Chapter of the American Society of Farm Managers and Rural Appraisers, available on-line at http://www.calasfmra.com/landvalues/2003/Reg01.pdf.

some sort of permit for removal. There are regulatory tools such as “landowner assurances” that work with private landowners to address these concerns.

In addition, above-grade impoundments always pose a risk of dam failure. Crops could be eaten by wildlife inhabiting wetlands. Flooding of fields can accelerate leaching of pesticides, herbicides, and nitrogen, thereby increasing the risk of groundwater contamination. Vehicle access to densely vegetated riparian reaches is difficult. On the plus side, actively managing riparian vegetation provides an opportunity to selectively remove problematic invasive weeds.

Erosion control within the Bypass is actually *not* encouraged. The Bypass’ flood conveyance capacity would be reduced if sediment were not flushed regularly.

Remove or Stabilize Mine Waste

POCs addressed: mercury

Description

Various conventional technologies exist to reduce the load of contaminated sediments entering water bodies. These include:

- Erosion control – common practices such as drainage modifications, re-grading, re-vegetation and slope stabilization;
- Containment and stabilization/encapsulation – application of non-contaminated covering soils or encapsulation using soil stabilizers; and
- Removal and disposal – excavation and disposal in a landfill for highly concentrated mercury-containing wastes.

Benefits

Mine waste cleanup addresses contamination of local waterways from erosion and leaching, both at mine sites and in contaminated streambanks. Mine site cleanup will be required by the Cache Creek mercury TMDL for several mercury mines in that watershed. It is estimated that on the order of 95% of the current mercury load can be stopped through effective site remediation. However, the net load reduction of total mercury entering the Bypass would be approximately 5% of the total load from that watershed, thus less than 10 lbs/yr.

Costs

Remediation of the Sulphur Bank Mercury Mine by Clear Lake has taken over a decade and is still not completed. Costs to date exceed $12 million for remediation work alone, not including numerous studies over the past two decades.

Mine remediation projects in the Cache Creek and Lake Berryessa watersheds could cost on the order of $5 million per site, depending on the size of the site and local conditions.

Other Considerations

Many of the abandoned mercury mine sites are on land now owned and managed by the USBLM. USBLM would be responsible for cleaning up contaminated areas on those properties. Private landowners, who generally inherited similarly contaminated sites, would be responsible for their land. In both ownership situations, funding would be the primary concern.

There is currently considerable uncertainty regarding a third party's liability associated with cleaning up contaminated property. At a minimum, there would be a delay in evaluating a property owner's obligation and ability to conduct the remediation. The load reduction provided by a mine remediation project in the Cache Creek or Putah Creek watersheds would primarily benefit local water quality. Loads to the Bypass are already reduced significantly by deposition in streambanks, lakes and settling basins.

Manage Water Resources for Water Quality Benefits

Recognizing that local water resources are heavily managed for irrigation and flood control, control measures that could improve water quality by altering water management practices are described.

Minimize POTW Discharges to the Bypass

POCs addressed: aluminum, bacteria, boron, mercury, salinity

Description

City of Woodland, City of Davis, and UC Davis campus POTW effluents with relatively high salinity are discharged into Bypass tributaries or directly into the Bypass. These sources could be applied to land seasonally or discharged instead into the Sacramento River.

The City of Woodland has and may continue to investigate the viability of discharging its effluent directly into the Sacramento River near the Feather River confluence. The City of Davis is also investigating, as part of its Master Planning process, the viability of discharging its effluent directly to local farmland or into the Sacramento River south of West Sacramento.

Benefits

Salinity in the Yolo Bypass in the vicinity of removed POTW effluent discharges (Woodland or Davis) would decrease marginally during the dry season if POTW effluent were diverted out of the watershed.

Costs

Land application of wastewater would incur costs to purchase or lease the land (several thousand acres), install pipelines or irrigation channels, and manage the land and water. The City of Woodland estimated that total 20-year life-cycle costs to change its current method of effluent disposal from surface water discharge to reclamation via irrigation of fodder crops would be approximately $90 million (ECO:LOGIC Engineering, 2003). Offsetting benefits of increased land value and crop sales were not considered.

The City of Woodland estimated that total 20-year life-cycle costs to change its current effluent discharge point from Tule Canal in the Bypass to the Sacramento River would be approximately $18 million (ECO:LOGIC Engineering, 2003). Cost associated with installing and operating pipes from the City of Davis across the Bypass and through West Sacramento would be similar.

Local irrigation costs would increase as water would need to be imported to compensate for the loss of wastewater discharges.

Other Considerations

Discharging treated effluent to land would not be effective during the wet season when soils are saturated. Recent Waste Discharge Requirements in the Central Valley have increased treatment requirements for land disposal in recognition that the water could impact drinking water aquifers.

Growers in the Bypass rely on urban runoff and municipal wastewater discharges for irrigation purposes. Removing this water supply may harm local agricultural operations.

Manage Water Use in Bypass Wetlands

POCs addressed: aluminum, mercury, organic carbon, pesticides

Description

Wetlands have been found to effectively remove many pollutants if managed for that purpose. Various parcels within the Bypass are managed differently, creating a mosaic of wetland types. These lands can potentially be managed to improve water quality while also providing benefits such as flood retention, recreation, and wildlife habitat.

Benefits

Sediment removal efficiency in wetlands can vary with settling velocity of the particles and the hydraulic characteristics of the system, (e.g., retention time, depth, aspect ratio, percent open water area). However, wetland systems designed to remove other pollutants, such as nitrogen, typically will be over-designed with respect to suspended solids removal and systems can generally be expected to produce TSS levels close to background concentrations. Background concentrations are typically in the range of 3 to 15 mg/L and are the result of vegetation decomposition and wildlife activity. Many other POCs such as other metals, organic material and pesticides associated with sediments would also be removed.

Costs

Costs for altering wetland management practices would come from developing management plans and monitoring, in addition to any control structures. A managed wetland project would cost in the range of $20,000-$50,000 per acre (pers. comm., Tom Cannon, Wildlands, to S. McCord, 2/9/05).

Other Considerations

Residence time, seasonality of flows, soil types, plant communities, and influent quality can all impact pollutant removal rates.

Hardness and salinity, including boron, tend to increase through wetlands by the process of evaporative concentration. Heavy wildlife use of wetlands tends to increase fecal coliform concentrations.

In a national pilot study of mercury contamination in aquatic ecosystems, USGS found that wetland density (area of wetlands per area of watershed) was the single most important basin-scale factor controlling methylmercury production (Brumbaugh et al., 2001). The only local study on this issue found that the Cache Creek Nature Preserve wetlands functioned as a clear source of methylmercury to lower Cache Creek (Slotton and Ayers, 2004). The Delta mercury TMDL is expected to recommend that there be no net increase in methylmercury loads from restored marshes and new water impoundments.

Because sulfate-reducing bacteria tend to drive the methylation process, it is believed that limiting the available sulfate could be a key to minimizing the rate of methylation. The most concentrated sources of sulfate are mineral springs in the Cache Creek watershed (Domagalski et al., 2004). However, the highest concentration of sulfate enters the Bypass through the Ridge Cut (Schemel et al., 2002).

Costs and potential benefits of projects to control methylation cannot be generated until specific projects are identified.

Alter Inter-basin Water Transfers

POCs addressed: boron, salinity

Description

Inter-basin water transfer refers to the delivery of water from one watershed (basin) to another. Two major options are considered:

- Much of the Colusa Basin Drain water is discharged into the Sacramento River. More water could be diverted from the Drain through the Knights Landing Ridge Cut, which discharges into the upper Bypass.
- A low-flow fish passage could be constructed in the Fremont Weir. Water from the Sacramento River would be diverted continuously through the passage.

Water from Putah Creek is diverted at Lake Solano and largely transferred out of the watershed to Solano County for irrigation and potable supply. Diverting less water could provide greater dilution in lower Putah Creek and in the lower Bypass. A settlement agreement provided 50% greater flows to lower Putah Creek, along with a winter “pulse” flow to encourage salmon spawning. However, because allocations of that water have been determined by court ruling, additional flows are considered relatively unavailable.

Benefits

Colusa Basin Drain water diverted into the Bypass would provide additional water for irrigation and some dilution for wastewater dischargers. Monitoring results presented above indicate that water quality of this source is similar to water found currently in the Bypass.

Sacramento River water diverted through a low-flow passage in the Fremont Weir would provide some year-around, high-quality water to the Toe Drain. This water would encourage fish to migrate upstream through the Bypass while providing some dilution for wastewater dischargers.

Costs

There would be only minor costs associated with any capital improvements and maintenance associated with re-routing additional flows from the Colusa Basin Drain. Additional costs would be associated with addressing extensive regulatory compliance issues and negotiations with local water users.

Designing and constructing a low-flow passage through the Fremont Weir and purchasing water rights would incur engineering costs. Additional costs would be associated with addressing extensive regulatory compliance issues and negotiations with local water users. Current activities are aimed at determining project feasibility and estimating these costs.

Other Considerations

Colusa Basin Drain water is generally considered to be of poor quality. Farmers in the Bypass are generally opposed to this project because of the potential for more regulatory concerns associated with the supply of water with relatively poor quality.

Water diverted from the Sacramento River through a low-flow passage would be designated primarily for salmon migration. It would likely not be available for local irrigation. There are no major water quality concerns with this source.

WATER QUALITY MANAGEMENT PLAN

This section represents the management plan for addressing the prioritized POCs. The goal of the management plan is to set forth a series of actions that will result in achievement of water quality objectives appropriate for the Yolo Bypass. This plan is intended to be implemented in an "adaptive management" framework: implementing control measures to address clear problems, learning more to address important knowledge gaps, and reacting to unforeseen effects.

The general components of the plan to address water quality issues in the Bypass, generally in order of most preferable first, are as follows.

- Implement control measures. Implement feasible and cost-effective control measures such as described previously in this report.
- Undertake research and special studies. Conduct focused studies that improve the conceptual model for certain POCs or that aid in quantifying effectiveness of control measures.
- Monitor water quality. Monitor water quality to improve our ability to detect changes in water quality and to quantify linkages in the conceptual models for various POCs.
- Conduct site-specific objective or beneficial use studies. Address POCs coming from predominately natural and uncontrollable sources.
- Participate in future stakeholder activities. Participate in related stakeholder forums and in the development of plans and policies that directly impact water quality in the Bypass.

The following sections describe ongoing and planned activities and recommends enhancements to those activities and additional activities. Future stakeholder activities are also suggested at the end of this section. These activities also give attention to water quality in the Bypass. For low priority POCs, those that do not appear to be exceeding identified thresholds for concern, focused actions are deferred. Water quality related to these POCs will likely improve as a by-product of actions focused on improving conditions related to other POCs. The application of these components to each POC is summarized in Table 14.

Table 14. Summary of recommended options for addressing the POCs.

POC	Recommended Components for Addressing POCs			
	Controls	Study	SSO	Defer
Bacteria	X	X		
Total coliform				
Fecal coliform				
E. coli				
Boron	X		X	
Metals				
Aluminum	X		X	
Chromium				X
Copper				X
Lead				X
Mercury	X	X		
Selenium				X
Nitrate				X
Organic Carbon	X	X		
Total organic carbon				
Dissolved organic carbon				
Pesticides and Herbicides				
OCs (DDE)				X
OPs (Chlorpyrifos and Diazinon)	X			
Carbamates (Diuron and Methomyl)	X			
Salinity	X		X	
Total Suspended Solids (TSS)				X

Implement Control Measures

The previous chapter outlined and discussed a number of potential control measures relative to the POCs. A number of the potential control measures discussed are not appropriate or practical due to the cost and other considerations related to the measure. However, some measures are appropriate and cost effective for addressing at least some of the POCs. The control measures that were determined to be applicable and effective after evaluating all of the considerations are included here as recommended activities. These control measures address multiple POCs and represent activities and projects that appear most feasible and reasonable at this time. Expected effects are described, although generally not quantified in scale or benefit because of the lack of information currently available.

Improve Source Water Quality

Expected Effects: Reduced loads of boron and salinity to the Bypass. Recommended investigations will determine benefits to agricultural water users in the Bypass.

The City of Davis plans to construct four to six new deep (> 700 ft) wells during the next five years to obtain approximately 4600 acre-feet per year of water in place of water from intermediate depth wells. This water would amount to approximately 30% of the City's current annual water production. Water from deeper wells has an average TDS concentration of 380 mg/L versus 680 mg/L for water from intermediate depth wells. Therefore, salt loading in the City's water supply is expected to be reduced by approximately 3.8 million pounds per year. Water from the deep wells will also be much softer than water from intermediate depth wells, which will in turn reduce salt usage in water softeners. The lower salinity source water and reduced water softening discharges are expected to reduce influent wastewater TDS concentrations by approximately 150 to 200 mg/L (Rob Beggs, Brown & Caldwell, pers. comm. to S. McCord, 3/4/05).

The City of Woodland has already drilled deeper test wells and found unexpectedly high salinity there (Gary Wegener, City of Woodland, pers. comm. to S. McCord, 3/17/05).

It is recommended that:

- The City of Woodland continue to investigate the benefits of constructing deeper wells for drinking water supply; and
- The Cities of Davis and Woodland continue to investigate the feasibility of obtaining rights to withdraw water from the Sacramento River.

Conduct Outreach and Education

Expected Effects: Reduced loads of all POCs. Actual water quality benefits cannot be estimated accurately.

Outreach and education that would help to reduce POCs in the Bypass include:

- Conduct general stormwater management outreach and education;
- Conduct targeted outreach to promote IPM practices and optimal use of pesticides applied outdoors to reduce pesticide loads;
- Conduct targeted outreach to promote the use of “doggy bags” to reduce bacteria loads;
- Conduct mercury-specific outreach and education;
- Encourage alternatives to conventional water softeners in the Cities of Davis and Woodland to reduce salt loads; and
- Conduct outreach and education to potential swimmers in the Bypass, such as farm workers and recreational visitors, that bacteria levels are high and that the water is unsafe for drinking or swimming.

Implement Agricultural BMPs

Expected Effects: Reduced loads of pesticides to the Bypass. Given that agriculture appears to be the major source of pesticides in the Bypass, large-scale implementation of these BMPs are expected to significantly reduce pesticide loads.

Several control measures should be pursued to reduce pesticide concentrations in agricultural runoff:

- Enhance IPM programs in agricultural areas;
- Encourage the use of pest resistant varieties for the various crops grown in the watershed if appropriate;
- Encourage the use of reduced risk pesticides where applicable;
- Minimize erosion and sediment transport from agricultural lands through appropriate BMPs. Also, plant fescue in tailwater drains where practical to enhance particle setting;
- Implement irrigation and pesticide application BMPs to minimize runoff of pesticides; and
- Encourage farmers to limit use of more water-soluble pesticides (OPs & carbamates).

Implement Livestock BMPs

Expected Effects: Reduced load of pathogens to the lower Bypass.

Investigate the feasibility and benefits of livestock BMPs that minimize discharges of manure to waterways in the Bypass. This BMP would focus on the approximately 9,000-acre area in the southern Bypass on which cattle graze.

Support Enhancements to the Cache Creek Settling Basin

Expected Effects: Reduced load of metals to the Bypass. Total mercury loads could be reduced by an additional 20% beyond the Basin's current removal efficiency.

Enhance and/or maintain the Cache Creek Settling Basin to reduce sediment loads. Ancillary benefits would be to reduce loads of sediment-associated POCs including aluminum, mercury, and some pesticides;

Develop and Enforce New Development Guidelines

Expected Effects: Reduced load of bacteria, organic carbon, and pesticides to the Bypass. Benefits are more likely to be realized locally rather than in the Bypass.

Minimize POC loads from new urban development by implementing municipal stormwater management plans' new development programs.

Undertake Research and Special Studies

Several knowledge gaps have been identified through the evaluation of available information and the development of this plan. Results from the ongoing or planned studies described in this section will improve the conceptual models for POCs and thereby provide a better foundation for future control actions. Recommendations for improving or focusing the studies to improve the conceptual model for various POCs are also provided.

Conduct Pilot Sediment Study in the Northern Yolo Bypass

At Fremont Weir, accumulated sediments have been removed in 1986, 1987, and 1991, from the west, central, and east portions, respectively, restoring the areas to design grade. In the 2005-2007 period, 1-3 ft of sediment will be removed from the west and central portions again, to a distance approximately 3/4 miles south of Fremont Weir. DWR is conducting a pilot study to look for trends in quantity and types of sediment that drop out near the weir, trying to identify the primary water source of the deposited sediment.

It is recommended to measure aluminum, mercury, and pesticides in soils as part of this study. Broaden the spatial scale to encompass other areas in the Bypass if funds allow.

Conduct Colusa Basin Drain Diversions Study

Numerous stakeholders have come together to develop a proposed two-phase study to evaluate water quality within the Colusa Basin Drain, as well as eventually to evaluate the potential benefits of discharging into the Yolo Bypass instead of into the Sacramento River. The first phase will characterize the water in the Drain and consider the effects of its discharges on downstream users. A data summary report of accumulated information from such sources as local water districts, the USGS, state and regional regulators, DWR, California Department of Pesticide Regulations, California Rice Commission, City of Woodland, and CA Department of Fish and Game regarding the flow and water quality in the Colusa Basin Drain and the Knight's Landing Ridge Cut is scheduled for completion in early 2005. The results of this study will guide future monitoring activities that the stakeholders may propose. Depending on the results of Phase 1, the second phase will consider alternatives for improving water quality for downstream users.

Recommendations for Phase 2 are to:

- Include monitoring for all high and medium priority POCs; and
- Address the potential impacts of additional mercury load caused by diverting additional water from the Colusa Basin Drain through the Bypass.

Conduct Sediment Methylation Study

The USGS, in collaboration with other project partners, is planning a field study to measure mercury methylation rates in various wetlands. A summary of this project is not yet available.

Conduct Wetland Management Study

Wildlands, Inc., owns and manages a 400-acre property just south of the Knights Landing Ridge Cut. They have water rights totaling approximately 10 cfs and can manage the property as they see appropriate. Consequently, Wildlands has practically unrestricted access to and control over the land and water supplied to it. Wildlands has proposed to conduct an adaptive management experiment to treat Knights Landing Ridge Cut water through its wetlands.

It is recommended to track progress in this study, if funded.

Investigate Vector Control Pesticides

Vector control pesticides are applied in and adjacent to the Bypass under certain circumstances. It is recommended to investigate the potential loads of these pesticides.

Conduct Desalinization Research

Research is underway at a national level to reduce the cost of RO brine disposal. The focus is on reducing the amount of energy consumed to operate with zero liquid discharge using dual-stage RO units, crystallizers, and solar evaporation ponds (ASCE, 2005).

It is recommended to track results of research and pilot studies that address RO treatment systems and brine disposal.

Conduct Bacteria Special Study

With respect to bacteria source loads from wetlands, a substantial portion of the measured total coliform load appears to be from waterfowl. Because waterfowl and wetlands are generally encouraged, it must be recognized that the deleterious coliform by-product may be largely unavoidable.

It is recommended to investigate the feasibility of attaining current bacteria objectives in the Bypass. If attainability is infeasible, conduct a use attainability analysis pursuant to USEPA regulations to determine if de-designation of the swimming use (REC-1water contact recreation) is appropriate. Agricultural uses will remain problematic.

It is also recommended to conduct a bacteria source tracking study. The first step is to characterize the measured levels of bacteria as human or non-human origin. The next steps would be (1) to characterize non-human bacteria further, such as distinguishing bird sources from cattle sources, and (2) to determine the presence or absence of human viruses.

Conduct Salinity Source Control Study

No feasible control measures that could effectively reduce salinity loads from agricultural areas have been identified. It is possible that the Cities of Davis and Woodland and UC Davis could reduce salinity levels in wastewater effluent through source control. However, the actual water quality improvement in the Bypass would be negligible. These entities should conduct salinity source control studies, with a focus on any significant industrial or commercial sources and water softeners. Results from this study may justify the development of SSOs for salinity and boron in the Bypass. The City of Woodland is currently investigating salinity sources in its service area.

It is recommended to:

- Support the City of Woodland salinity source identification study; and
- Support the UC Davis EC study being funded by the Cities of Davis and Woodland.

Conduct Tertiary Treatment Benefits Study

It is recommended to investigate the costs and benefits of installing tertiary treatment processes at the City of Davis and City of Woodland municipal wastewater treatment facilities in relation to reducing bacteria loads and/or protecting recreational and agricultural uses in the Bypass.

Investigate Feasibility of Improving Migratory Fish Passage

Salmon have been found in lower Putah Creek in late 2003 and 2004 in response to pulsed flows from Lake Berryessa. Projects to open Cache Creek and the Fremont Weir to fish passage are in various stages of development. The impacts of altering flows, particularly through Fremont Weir, on water quality are generally expected to be beneficial. How these projects impact the needs for proposed control measures is undetermined.

It is recommended to participate in the development and implementation of plans to enhance fish passage through the Bypass.

Develop a Water Quality Model for the Bypass

Our ability to quantify water quality conditions in the Bypass, with a reasonable level of statistical assurance, is restricted now by the disparate condition of the available data. Developing a numerical model of the Bypass' hydrology, sediment transport, and pollutant loads would be feasible by linking the available hydrologic model with a comprehensive water quality database. All of the special studies and monitoring planned or recommended as part of this plan would be used as input to the model.

Monitor Water Quality

Monitoring water quality regularly over a long period and at multiple locations provides an opportunity in the future to detect changes in water quality and to quantify linkages in the conceptual models for various POCs. Other entities have been monitoring water quality in the Bypass concurrent with this project. Because results from those activities are not yet available, several are noted here for future reference.

Monitor Water Quality in the UC Davis Campus Arboretum Waterway

Since the UC Davis Campus Arboretum Waterway ("Arboretum") receives no inflows during dry weather, except for incidental irrigation overflows, algae blooms are common during the summer months. The campus is currently planning a project to reroute treated water from the UC Davis campus wastewater treatment facility through the Arboretum to provide a source of fresh water during dry weather. The design would also allow for treatment of Arboretum water by the treatment facility when excess capacity is available (e.g., at night). This project is intended to improve water quality in the Arboretum, and support possible water reclamation projects on campus in the future. However, the potential for methylmercury generation through the arboretum should be recognized and addressed by monitoring the influent and effluent from the Arboretum to assure that there is no significant net increase in methylmercury being discharged.

Monitor Local Methylmercury Concentrations

The Cities of Davis and Woodland have been requested by the Regional Board to characterize methylmercury concentrations in the effluent from their wastewater facilities. If concentrations are elevated then the Cities may be requested to conduct special studies to determine how to reduce those concentrations.

Yolo County has monitored mercury and methylmercury in and around the Cache Creek Nature Preserve for the past three years (fall 2000 through summer 2003) and just renewed the effort for another three years. Additional mercury monitoring may be required as part of the Cache Creek mercury TMDL.

Monitor Pesticide Concentrations in Bypass Inputs

USGS is currently measuring pesticide concentrations in the various inputs to the Yolo Bypass, including Knight's Landing Ridge Cut, during the winter.

Monitor Receiving Waters for NPDES Permittees

Wastewater discharges regulated under the NPDES permitting program monitor their effluent and receiving water quality on a regular basis. Monitoring frequency, constituents monitored, and sample locations are determined based on site-specific water quality concerns and spelled out in individual permits.

Municipalities and owners of construction sites disturbing greater than one acre of land are required to obtain coverage under separate NPDES stormwater permit programs. No monitoring is required of these permittees unless problems are identified. While urban uses of OP pesticides have been phased out, homeowners generally select other available pesticides rather than use other pest control measures. Any future monitoring of water quality in urban runoff should include analyses for current use pesticides.

Monitor Under the Agricultural Discharge Permit Waiver Program

The Conditional Waiver for Irrigated Lands in the Central Valley has a monitoring requirement that has resulted in the development of additional monitoring sites within the Yolo Bypass. The Yolo County agricultural community is working with the Sacramento Valley Water Quality Coalition to coordinate the monitoring requirements contained within the Conditional Waiver. The agricultural waiver program requires dischargers to conduct a toxicity identification evaluation if significant toxicity is found after a resampling event. Three sites monitored for this study are also being monitored for the agricultural waiver program using the 96-hour exposure test: Toe Drain, Z Drain, and Tule Canal. No additional monitoring beyond these requirements is recommended.

Monitor Bypass Hydrology and Geomorphology

DWR regularly monitors hydrology and geomorphology, water quality, aquatic resources, and terrestrial resources in the Bypass. Water quality indicators monitored include Secchi depth, conductivity, temperature, pH, and Chlorophyll *a* (all at the Little Holland "stairstep", which is downstream of the Toe Drain sample site); plus nutrients, cations, and organic matter (all at three sites in the Bypass along the eastern margin of the Yolo Bypass and in local tributaries Ridge Cut, Cache Creek, Willow Slough, and Putah Creek). They also store these data in the Bay Delta and Tributaries (BDAT) database (http://bdat.ca.gov). Monitoring is not occurring now, but will be again starting in 2006 pending CALFED funding approval.

Monitor to Estimate Mercury Loads

The Regional Board is collecting mercury data in the Bypass under a CALFED-funded project to estimate a mercury mass balance of the Delta. One of the project's aims is to develop more detailed mass balances for these areas: 1) above Lisbon, 2) Lisbon to start of flooded islands, and 3) in the flooded Liberty and Little Holland Tracts (Chris Foe, Regional Board, pers. comm. to S. McCord, 3/4/05).

Conduct Fish Tissue Sampling

The concern for some POCs, particularly pesticides and mercury, is bioaccumulation and its effects on top predators. However, no comprehensive monitoring of resident fish species has been conducted. A special study to assess fish body burden of bioaccumulative POCs and other potential POCs such as trihalomethanes is recommended. This information would serve to improve the understanding of pollutant fate in the aquatic food web and to support fish consumption advisories.

Develop a Sustainable Baseline Water Quality Monitoring Program

All of the monitoring activities described in this section are focused in time and location. The benefits of a comprehensive, regular monitoring program would be to track progress towards attaining water quality objectives and to put short-term or spatially limited monitoring results in perspective. Routine monitoring should be conducted to improve the understanding of baseline conditions, track water quality trends, and identify new POCs.

Conduct Site-specific Objective or Beneficial Use Studies

Changes in water quality standards may be appropriate for aluminum, salinity and boron because the current standards are either infeasible or not applicable. Water quality standards may be changed by altering the designated beneficial use (which changes the applicable water quality criteria), developing a site-specific water quality objective, or both. In any of these cases, a study would need to be conducted to support a change in the water quality standard and ultimately amend the Basin Plan.

To change a beneficial use designation, a Use Attainability Analysis (UAA) would need to be prepared. Under federal regulations, a beneficial use may be de-designated if it can be demonstrated that the designated use is not attainable because:

- Naturally occurring pollutant concentrations prevent the attainment of the use; or
- Natural, ephemeral, intermittent or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating State water conservation requirements to enable uses to be met; or
- Human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place; or
- Dams, diversions or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the water body to its original condition or to operate such modification in a way that would result in the attainment of the use; or
- Physical conditions related to the natural features of the water body, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life protection uses; or
- Controls more stringent than those required by sections 301(b) and 306 of the Act (Clean Water Act) would result in substantial and widespread economic and social impact. (40 CFR 131.10 (g) and (h)).

Changes in water quality objectives, or the development of a site-specific water quality objective for a specific water body, are governed by federal and state law, and must be approved by USEPA. In California, water quality objectives must “ensure the reasonable protection of beneficial uses and the prevention of nuisance.” When adopting or changing water quality objectives, the Regional Board must consider a number of factors, which include:

- Past, present and probable future beneficial uses of water;
- Environmental characteristics of the hydrographic unit under consideration, including the quality of water available thereto;
- Water quality conditions that could reasonably be achieved through the coordinated control of all factors which affect water quality in the area;
- Economic considerations;
- The need for developing housing within the region; and
- The need to develop and use recycled water. (CA Water Code §13241.)

In other words, a change in a water quality objective must still provide reasonable protection for the beneficial uses designated within the Basin Plan.

Another option is to change the water quality objective as it is documented in the Basin Plan. Some dischargers may be able to change a water quality objective or criteria *as it applies to them* in a permit or a basin plan amendment through the development of a Water Effects Ratio (WER). The development of a site-specific objective through a WER is usually associated with numeric water quality criteria for metals developed by USEPA for aquatic life species. In general, the national numeric water quality criteria developed by USEPA are derived through a literature review of aquatic toxicity studies and tests performed in laboratory waters that often are not representative of natural waters. The USEPA acknowledges that because of a variety of physical and chemical characteristics of water bodies (e.g. pH, hardness, alkalinity, suspended solids, salinity, etc.) throughout the country that the national criteria might be either under- or over- protective for some water bodies. WERs are used to account for “real-world” conditions that may impact the toxicity of metals towards aquatic life. USEPA guidance has outlined three procedures that can be used to derive site-specific objectives in these circumstances.

- The Recalculation Procedure is intended to take into account relevant differences between the sensitivities of aquatic organisms in the national data set and the sensitivities of organisms that occur at the site.
- The Indicator Species Procedure provides for the use of a WER that is intended to take into account relevant differences between the toxicity of the metal in laboratory dilution water and in site water.
- The Resident Species Procedure is intended to take into account both differences in sensitivities of aquatic organisms and differences in toxicity of laboratory dilution water and site water. (USEPA, 1994).

Potential studies necessary to implement changes in beneficial uses or water quality objectives for specific pollutants are discussed further below.

Aluminum

Aluminum may be a viable candidate for the development of a site-specific objective through a WER for several reasons. First, the national recommended ambient criteria of 87 ug/L for aluminum is a qualified criterion that may not be applicable in all watersheds. The USEPA’s 1998 National Recommended Water Quality Criteria for aluminum contains a footnote to the 87 ug/L that documents why a WER might be appropriate for aluminum in some situations like the Yolo Bypass. In particular, the footnote states that the 87 ug/L value is based on a toxicity test with striped bass in water with a low pH (6.5-6.6) and low hardness (< 10 mg/L). The average pH and hardness for the in-Bypass monitoring sites was 8.0 and 223 mg/L, respectively, indicating that a WER is appropriate.

Excluding outliers in the dataset, the aluminum concentrations of in-Bypass water samples approximates the natural aluminum content of native soil. The recommended control measures are not expected to reduce aluminum concentrations sufficient to achieve the recommended criterion. Moreover, the aluminum associated with native soil may not be reactive (i.e., toxic) to aquatic biota. Therefore, aluminum should be addressed by developing a site-specific objective, specifically a Water-Effect Ratio (WER) using USEPA protocol.

The WER would effectively take into account the local water quality characteristics that mitigate toxicity of aluminum to aquatic life. Initial work should consist of range-finding toxicity tests, whereby several candidate species of aquatic biota would be evaluated for use in the actual WER testing. Based on results of the range-finding tests, a small number of species could be selected for the WER tests. Subsequent work would entail performance of the actual WER study using the selected species along with consultation with and evaluation by an expert review panel.

Boron and Salinity

Salinity and boron may be eligible for site-specific objectives and basin plan amendments because the criteria interpret a narrative objective by using a United Nations report's recommended Agricultural Goals. The United Nations report clarifies that the most conservative goals for salinity and boron are intended to apply worldwide, regardless of the climatic conditions and that the actual level of salinity and boron may change depending on a number of factors including rainfall and other natural conditions. In response to issues and concerns raised regarding the applicability of the recommended goals contained in the United Nations report to the Yolo Bypass area, the State and Regional Board are working with dischargers in the Yolo Bypass area to determine what may be an appropriate objective for the reasonable protection of the agricultural beneficial use.

In order to determine what may be an appropriate level of protection, UC Davis researchers have developed a model to determine how the EC of a given irrigation water supply affects crop production while taking annual rainfall into account (Isidoro-Ramirez et al., 2004). The referenced report marks the completion of work initially proposed by UC Davis to the Regional Board in January 2003. The model relates the EC of the irrigation water to the seasonal average root zone salinity, expressed as the electrical conductivity of the saturated paste. The model considers the timing and quantity of applied irrigation water, the quantity and distribution of rainfall, and realistic assumptions related to soil water principals based on soil type. This model was used to evaluate site-specific conditions for the Putah Creek reach downstream of the UC Davis treatment plant based on consistently conservative assumptions. Model results from simulating yields of salt-sensitive crops over the past 53 years of rainfall indicate that using 1,100 uS/cm as the threshold EC value for irrigation water is considered protective for all agricultural uses of the water in the area. These same researchers are in the process of developing protective EC values for the Yolo Bypass.

In addition, the UC researchers are working with boron experts from the University of California, Riverside to determine how the model may be adjusted to determine appropriate and protective values of boron for the Yolo Bypass area.

Once the studies have been completed, UC Davis, the Cities of Woodland and Davis and other stakeholders will work with the Regional Board to determine if a basin plan amendment is necessary to implement the objectives developed through the study process.

Participate in Future Stakeholder Activities

Several future stakeholder activities are recommended for inclusion in the Water Quality Management Plan in this section. The activities provide mechanisms for tracking and participating in the development and implementation of projects that impact water quality in the Bypass.

Conduct Stakeholder Meetings

Stakeholders, such as those comprising the Stakeholder Advisory Group, should meet on a regular basis to provide a forum for tracking ongoing studies and monitoring, to coordinate activities, and to share results of the recommended control measures and studies.

Develop a Master Yolo Bypass Water Quality Database

As monitoring activities increase, so does the need for accurate and expedient data management. Enhanced data management can be achieved through the development of a relational database designed to store and manage the monitoring data. A comprehensive data management application would need to satisfy the following data management objectives: (1) efficient storage of all data in a geo-referenced format, (2) enhanced data validation and qualification of water chemistry environmental data through the "onboard" storage and evaluation of water chemistry QA/QC data, (3) robust data manipulation and analysis capabilities through user-friendly graphical user interfaces (GUIs), (4) capability to upload to the SWAMP database, and (5) the capability of the application to be modifiable as needs change over time. The ultimate goal of a database would be to provide a powerful, easy-to-use water quality data management system to stakeholders in implementing the Yolo Bypass Water Quality Management Plan.

Track and Participate in the Development of Relevant Environmental Management Plans and Policies

Several plans and policies that impact water quality management in the Yolo Bypass are under development. The most relevant projects are described in this section, in order of larger to more local focus. It is recommended that stakeholders track or participate in the development and implementation of these plans and policies.

California Drinking Water Policy

Drinking water is regulated by the California Department of Health Services, which issues drinking water standards, and the State and Regional Boards, which designate waterways as having beneficial use of municipal and domestic water supply and protect them for those beneficial uses. Current plans and policies lack water quality objectives for several known drinking water constituents of concern and implementation strategies to provide effective source water protection. A multi-year effort is underway to develop a drinking water policy for surface waters in the Central Valley. The Central Valley Drinking Water Policy Workgroup, formed to develop and implement a work plan to provide the technical information needed by regulators to develop appropriate policy. Work plan tasks include water quality monitoring, pollutant load evaluations, and evaluations of potential control strategies to identify those that are reasonably attainable and cost effective.

Sacramento River Watershed Program

The mission of the non-profit Sacramento River Watershed Program (SRWP, see http://www.sacriver.org/) is to ensure that current and potential uses of the watershed's resources are sustained, restored, and where possible, enhanced, while promoting the long-term social and economic vitality of the region. The SRWP provides a network for building a basin-wide context to improve watershed health. It operates through consensus-based collaborative partnerships, coordination of research and monitoring, and enhancing mutual education among stakeholders. Recognizing that flood waters to the Bypass come from the Sacramento River watershed, this larger stakeholder group is an important link to source water quality.

Yolo County Integrated Water Resources Management Plan

The Yolo County Integrated Water Resources Management Plan (IRWMP) currently in review will update the County's 1992 water management plan. The IRWMP also will explore opportunities for cooperative action, serve as a countywide forum to identify and address concerns related to water resources, and help provide a framework under which local water management policies, projects, and programs could be formulated, evaluated, and implemented. Local agencies and stakeholders in Yolo County have been working together with DWR to complete this plan.

Volume 1 of the IRWMP provides information about the physical, institutional, and legal aspects of water management in Yolo County, including the management of water for agricultural, municipal, and environmental purposes. Volume 1 uses background information and data from existing reports, studies, programs, investigations, and planning efforts.

Volume 2, to be completed in 2006, will build upon the information provided in Volume 1. Volume 2 will contain an implementation plan to address surface water, watershed, groundwater, water supply reliability, and other water and environmental resources issues. Volume 2 will involve considerable stakeholder input to develop the plan.

Cache Creek Resources Management Plan

Yolo County has many on-going efforts to preserve its environmental lands including the Open Space and Recreation Element of the General Plan, the Habitat Conservation Plan, and the Cache Creek Resources Management Plan (CCRMP). Of these, the CCRMP is the most relevant for this plan because it specifically addresses water management and water quality. The CCRMP addresses a variety of issues relevant to managing the diverse resources within the Creek Channel from the Capay Dam to near the town of Yolo. The CCRMP drives land use activities and environmental restoration within the present channel banks and 100-year floodplain. Adoption of the CCRMP discontinued commercial mining within the active creek channel. The CCRMP also aims to:

- Improve channel stability;
- Minimize flood damage;
- Restore wildlife;
- Prescribe standards and regulations for initial channel smoothing and shaping;
- Recommend ongoing maintenance activities and creek restoration efforts;
- Provide year-round flows in many portions of the creek;
- Identify restoration project areas; and
- Provide buffers for existing and future agricultural for restoration and recreation areas.

Willow Slough Watershed Resources Management Plan

A planning process was initiated by the Yolo County Resource Conservation District, Yolo County Flood Control and Water Conservation District, Yolo County Community Development Agency, and the California Wildlife Conservation Board to explore the possibilities for managing natural resources throughout the Willow Slough watershed in an integrated manner. This two-year process involved the participation of numerous landowners; federal, state, and local agencies; and the general public, and culminated in 1996 with the development of a draft plan document. A final report is in progress (pers. comm., P. Robins to S.

McCord, 1/19/05). The list of possible implementation measures is organized into the following general categories:

- Construct impoundments,
- Manage riparian vegetation,
- Modify slough channels,
- Improve rangeland,
- Alter cultivation practices, and
- Implement other possible measures.

Yolo Bypass Wildlife Area Management Plan

The California Department of Fish and Game will begin a two-year project to prepare a wetland management plan for the Yolo Bypass Wildlife Area. Major goals for the plan are to:

- Provide for permanent flowing water;
- Restore wetlands to their natural function;
- Generate operating income through seasonal agriculture;
- Study mercury methylation in wetland environments; and
- Study management effects on salinity and pesticide concentrations in wetland runoff.

TMDLs

The only relevant TMDLs being developed by the Regional Board are for mercury in Cache Creek and the Delta. Phase 1 of the Cache Creek TMDL calls primarily for additional study, but the intent for Phase 2 is to reduce methylmercury concentrations and sediment mercury content eventually. The Delta TMDL will likely impose load and waste load allocations to sources of methylmercury into and from the Bypass.

It is recommended to participate in the development and implementation of the Clear Lake, Cache Creek, and Delta mercury TMDLs.

Pursue Water Quality Trading

It is recommended to promote the concept of water quality trading as a viable mechanism for implementing load reduction projects.

Address New POCs

Water quality impacts to the Yolo Bypass change over time because of several complex and dynamic processes, triggered by such things as agricultural practices, urban development, climate change, catastrophic events, and water management. In this dynamic environment, the list of POCs will likely change over time. The proposed research and monitoring programs will help to identify and quantify those POCs.

The same contacts used to call upon stakeholders convened for the development of this plan should be utilized to call for participation in addressing POCs identified in the future.

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Appendix 1. Stakeholder Meeting Minutes

APPENDIX 1-A.
YOLO BYPASS WATER QUALITY PLANNING PROJECT
CALFED Grant # WSP01-FP-0073

STAKEHOLDER GROUP MEETING #1
MEETING MINUTES

MEETING DATE: **JULY 25, 2003**

LOCATION: California Department of Fish and Game
Yolo Wildlife Area Headquarters
45211 County Road 32B (Chiles Road)
Davis, CA 95616

IN ATTENDANCE: Robin Kulakow, Yolo Basin Foundation (YBF)
Dave Feliz, California Department of Fish & Game
Armand Ruby, Larry Walker Associates (LWA)
Chuck Dudley, Dudley Ag
John McNerny, City of Davis
Jan Lowrey, Cache Creek Conservancy
Chris Erichsen, LWA
Christine Engel, City of Woodland
Marianne Kirkland, California Department of Water Resources, Division of Environmental Services
Casey Walsh Cady, Calif. Department of Food & Ag
Betty Yee, Regional Water Quality Control Board
- Central Valley
Mike Hall, Conaway Ranch

***NEXT MEETING*:** One will be scheduled in a few months.

ACTION ITEMS:

1. Ms. Kirkland asked for a copy of the Tule Canal study by Woodland.

2. LWA will check with DPR on up to date pesticide information

3. Ms. Walsh Cady get updated pesticide use information from her office.

4. Mr. Erichsen will distribute website information on the Sacramento River Basin Plan to participants

INTRODUCTIONS:

Mr. Ruby called the meeting to order and began introductions of attendees. Many people voiced an interest in participating in the project but are on vacation. He circulated a list of interested people and asked that participants add others if necessary. He went over the fact sheet that was distributed to everyone. This project is funded under a grant from the California Bay Delta Authority's Watershed Program (formerly known as CALFED). City of Woodland (City) is grant recipient and Christine Engel is City contact. Casey is the project liaison for CALFED. LWA is a subcontractor to the City. Chuck Dudley is working with LWA to fill in information about farming in the Bypass. The overall goal is to produce a comprehensive plan to improve water quality in the Yolo Bypass (Bypass). The project scope was written a few years ago and is very ambitious. The Bypass is a very complicated system from both a hydrological and water quality standpoint. It makes our job more difficult. It is not an in and out situation like a river. The big goal of today's meeting is to decide on essential parameters for the monitoring. The monitoring is on the critical path in the project. There are two years left on the grant, which must be completed by June 30, 2005. The monitoring portion of the project will last one year. It will start in October. The ideal would be monthly monitoring. Once the monitoring is completed the analysis and planning phase will start.

PROJECT OVERVIEW

Mr. Ruby reviewed the project goal, objectives and approach.

GOAL

The overall goal of the project is production of a comprehensive plan for improvement of water quality within the Yolo Bypass. Such plan will account for the diverse interests in and uses of the Bypass, and will aim to make the best and most reasonable use of funds available for that purpose.

OBJECTIVES

The objectives of the Yolo Bypass Water Quality Planning Project are:

1) Identify specific Pollutants of Concern (POCs) currently impacting the beneficial uses of surface waters in the Bypass and downstream Bay-Delta

2) Identify effective, implementable controls for the high priority POCs;

3) Develop a comprehensive management plan to improve water quality in the Bypass.

APPROACH

- Form an advisory group of Yolo Bypass stakeholders to participate in a collaborative process of developing the water quality management plan;

- Compile and evaluate existing water quality, flow, and land use information;

- Identify the current water quality issues and pollutants of concern (POCs) for the Bypass;

- Conduct a surface water quality assessment and monitoring program to quantify the POCs and their apparent sources within the Bypass;

- Assess whether the measured levels of POCs are causing impairment of beneficial uses of the Bypass;

- Identify and evaluate alternative controls to reduce significant sources of POCs, including where appropriate POTWs (Publicly-Owned Treatment Works), urban runoff, and agriculture;

- For those POCs for which effective controls appear technically or economically infeasible, investigate the applicability of current water quality objectives for these POCs and suggest site-specific objectives, pollutant trading, or other alternative approaches, as appropriate;

- Provide public education and obtain public input regarding potential methods for improving water quality in the Bypass, as well reducing loads on the Bay-Delta; and

- Produce a Water Quality Management Plan report containing a recommended program of implementation to reduce POCs that are degrading beneficial uses of surface waters.

Mr. Ruby briefly covered the agenda and the purpose of the stakeholder group. This is the first meeting of the group. The stakeholder group is essential to the success of the project. It will provide the local knowledge necessary to address the issues of monitoring and planning.

If there are pollutants that are not controllable under current projects, pollutant trading is a possibility. Monetary trades may also be used. A basin plan designates specific beneficial uses that must be maintained. There are not specific ones identified for the Bypass. There are uses defined for the Tule Canal though.

A participant asked why the City of Woodland interested in this project.

Mr. Ruby: The City is subject to increasingly stringent water pollution discharge standards. Very expensive upgrades would be necessary to meet the standards. The City has questions about the reasonableness of these requirements. Dilution is available when the Bypass is flooded. City effluent provides most of the water in Tule Canal. It is considered an effluent-dominated water way. This is a state issue. The City is interested in pursuing a watershed approach to meet the standards. State permit writers follow their defined priorities. With TMDLs (Total Maximum Daily Loads) the focus is the whole watershed. This project will expand the area of interest to the whole watershed. The watershed is defined as the Bypass for this project even though it is part of a larger watershed. The City is looking for options to meet the standards. Officials from Woodland, Davis and UCD are concerned about the need for significant rate increases to meet the state requirements. They are looking for options that seem reasonable. Some potential options: land disposal/reuse discharge to the Sacramento River north of Sacramento, and use of the Natomas Pipeline to discharge to Sacramento Regional Treatment Plant, although it is probably too late to participate in that project. It is important for the City not to act with a single point of focus. They need to look at the issues in a bigger context.

The main things to accomplish today are to discuss the role of the stakeholder group and discuss an approach to monitoring. The group needs to define parameters for monitoring. That information will provide the basis for the next step in developing a plan. The grant scope calls for quarterly stakeholder meetings. May need to meet every other month since project is compressed from 4 years to 2 years. Stakeholder group will get larger but have similar format to today. Stakeholders are encouraged to communicate with project managers in between meetings. Stakeholders will be asked to review work products. A monitoring plan will be sent out for review first. At the end of the project a report will be produced. The conclusion of the report will provide guidance for the regulatory process. Other issues that will be involved include the ag waiver. Ag monitoring is supposed to start in Jan. 2005. This project will provide information for that process.

The grant scope has funds for a facilitator. Mr. Ruby has spoken with Dave Ceppos but the group can decide if a facilitator is needed and who that will be. It is hard to decide at this stage. A group with the number of participants today is pretty manageable without a facilitator. That issue can remain on the table.

Monitoring Program Planning

LWA works on water quality issues primarily with governmental agencies. They work on surface waters primarily, not on supply. They work on ways to improve discharge quality. There are two paths of discharge from urban areas: storm water and treatment plant effluent.

Chris Erichsen has put together a number of resources for the stakeholder group (handouts were provided).

Water Quality Issues

There are a number of issues that pertain to pollutants of concern (POCs). The NPDES permit outlines the elements of concern:

Chlorine limits, a set of standards for oil, grease, total dissolved sediments, Bis2-ethylhexylphthalate, Lindane, organochlorine pesticides. DDT is still found in environment occasionally. It is called a legacy pollutant. The single largest pollutant in the Sacramento River is mercury. It is also a legacy pollutant. It was used in gold mining and as a result there is a lot of mercury in the system.

Trihalomethanes are the common pollutants in chlorinated systems. These chlorinated compounds are very toxic.

Several metals have been detected in the City's effluent, including: beryllium, aluminum, iron, selenium

The City is discharging selenium at lower levels than drinking water in Davis.

Boron is also a problem.

Electrical conductivity, dissolved salts: this is a big issue. Reducing electrical conductivity is required to protect salt-sensitive crops. Reverse osmosis is a treatment of last resort. Dissolved solids are not easy to treat. They don't settle out. Reverse osmosis is very expensive to install and operate. Could increase rates at least 10 times. It is very energy intensive and brine disposal is required after treatment.

There is a question about how real is the need for low conductivity water for ag (no strawberries are grown in the Bypass, and it is unlikely there ever will be any).

Levels of Coliform bacteria are used as an indicator of the effectiveness of chlorination systems. It is not a pathogen itself.

Standards have gotten much lower recently for several reasons. Monitoring can detect POCs at lower levels. Treatment plants can't always treat to such low levels.

Ms. Kirkland asked for a copy of the Tule Canal study by Woodland.

Mr. Ruby can send out Tule Canal permit elements if anyone is interested.

Ms. Walsh Cady asked if the list of water quality issues for Bypass goes beyond the list reviewed today. She also asked if a beneficial use designation can be changed.

According to Mr. Ruby and Ms. Yee, they can be changed but it doesn't happen often. Must do a beneficial use attainability analysis before any changes can be made. This is not a simple process. The State is interested in improving this process.

Mr. Ruby reviewed a table of beneficial uses for the Tule Canal. The Bypass is item 52 in the review document. The state defines the beneficial uses of Tule Canal as contact recreation (swimming) and agriculture production (crops that are sold unprocessed to community), among others. MUN stands for municipal use. MUN may apply even though it is not listed for the Bypass. Down stream of the Bypass, the Delta is designated MUN. Drinking water protection is an issue for CALFED. There is a Drinking Water program at the State. Betty was asked to track this issue for the group.

Ag uses of water include irrigation and stock water.

E = existing
P = potential

There is no industrial use since the Yolo Bypass is a floodway. Nothing permanent can be constructed.

Jones and Stokes Associates completed a recreation study of the Tule Canal in 2001. They included swimming, wading, fishing in the study. There was a question as to whether water testing is required for swimming. According to Mr. Ruby, Title 22 infers that beaches should be tested but not rivers. Local ordinances can require testing of water for swimming. Mr. Feliz noted that based on his experience in the Suisun Marsh hunting is defined as a contact sport for this purpose.

The importance of fish species using the Bypass was discussed. Fish habitat is an important use of the Bypass. Ms. Kulakow noted that several studies have been completed looking at the value of the Bypass for fish habitat and there are proposed projects to improve fish habitat.

Basin Plans set regulatory standards for watersheds. This is the fundamental context of the water quality issue. Water quality information is part of the Sacramento River basin plan on a website that Mr. Erichsen will get for the group.

This plan can reflect real beneficial uses even if they are not identified on the chart. This includes fish spawning and migration.

Mr. Ruby reviewed the list of water quality limits for the Bypass segment of the Sacramento River Basin Plan.

Mr. Ruby reviewed the state's Clean Water Act Section 303(d) list of impaired water bodies that do not meet standards. A separate set of requirements applies to these listed water bodies, including requirements to derive Total Maximum Daily Loads (TMDLs) for the offending pollutant(s). Lower Cache Creek, Lower Putah Creek, Delta Waterways, and the Sacramento River are listed.

The listing of unknown toxicity on Cache Creek was discussed. Unknown means there was toxicity observed to aquatic life but the reason was not determined. It could be anything: dissolved oxygen depression, turbidity, or pesticides.

The Tule Canal is known as an effluent-dominated waterway.

The hydrology of the Knights Landing Ridge Cut was reviewed. Mr. Dudley explained the mechanics of the Ridge Cut. The water level in the Ridge Cut is maintained at 24.5 feet during irrigation season. That was set to maintain a usable water level back to Colusa - Yolo county line. There is a permanent gate system at Knight's Landing and a seasonal weir at the bottom end of the Ridge Cut, at the Bypass. There is a winter operation of the weir and a summer operation. The weir comes out at the end of irrigation season. The level of the Sacramento River at Knights Landing determines if water goes into the Bypass. At high water it flows into the Bypass. Water flows into the river as long as the level of the river is lower than the Ridge Cut. Once the level exceeds the gate capacity at Knight's landing, the water from Colusa Basin Drain flows into the Bypass via the Ridge Cut.

The list of pollutant/stressors for the Colusa Basin Drain was discussed. POCs are found there that are not elsewhere.

Mr. Dudley asked how recently was this list updated. Mr. Ruby indicated it was updated in 2001 but many of the POCs could have been grandfathered in. Levels to qualify for listing are not standardized. They could be based on one sample taken years ago. There is a movement statewide to set standards for listing of pollutants. There is not consistency now.

Mr. Dudley pointed out that some of the listed pesticides are short lived or not used any more. Mr. Lowrey pointed out that the ag world is entirely different from 10 years ago. Diazinon is being phased out for most residential and commercial uses (ag uses will continue).

Ms. Walsh Cady asked if updated information is needed. Mr. Erichsen can look to see what is currently being applied in the field.

LWA will check with DPR on relevant information that is available.

Casey will ask for updated information from her office.

"Group A Pesticides" are organochlorine pesticides; these are mainly issues of the past.

Site Selection

What are the best sites? Look at best sites for both the irrigation season and the wet season.

Mr. Dudley recommended a site on the Tule Canal north of I-5 upstream of the City effluent discharge point. All irrigation discharges go in above this site.

Mr. Ruby said that they have asked Mr. Dudley to look at how the water works in the Bypass. LWA has focused information from previous water quality studies on points above and below the City points of discharge.

Mr. Feliz is interested in the quality of water that is being used to flood wetlands in the Yolo Bypass Wildlife Area (YBWA). He suggested a monitoring site north of Putah Creek to capture water discharge off the rice fields just south of I-80.

A participant asked about a point near the Ridge cut. A site between Ridge Cut and the City discharge point was discussed.

Ms. Walsh Cady asked about ongoing monitoring stations. USGS has a National Ambient Water Quality Assessment (NAWQA) site in Tule Canal north of I-80. They have been doing quarterly sampling since 1995. Other sites include: a USGS gauging station on Tule Canal north of I-5, and another NAWQA site on Cache Creek at Rumsey. Other agencies have stations and gauges scattered throughout the Bypass. NAWQA sites will be most useful since they measure toxic pollutants at low levels (but only during years with sufficient flow; e.g., not 2002). The NPDES dischargers also assess toxicity at the discharge sites for the City of Woodland, City of Davis, and University of California/Davis, on the Tule Canal, Willow Slough Bypass and Putah Creek, respectively. Yolo County has three ambient water quality stations along mid and lower Cache Creek. See Yolo County's Resource Management web site for details on this program. DWR is also doing some monitoring.

Mr. Lowrey asked if they want to be able to monitor all year round. Mr. Ruby replied that monthly monitoring is preferred to capture variation throughout the year.

Mr. Hall was asked about where Conaway Ranch gets its water. Water comes from the Sacramento River, Conaway Canal, and Willow Slough. They do not use the Willow Slough Bypass Water. In the winter the Willow Slough Bypass drains into Bypass. Conaway does not use water out of the Tule Canal. They capture Woodland storm water also. During the summer it is a closed system until the rice fields are drained.

It was agreed that it is a good idea to monitor below Fremont Weir during the winter. Currently DWR does not monitor flows there.

According to Mr. McNerney the City of Davis has two effluent discharge points on the Willow Slough Bypass. It is monitored regularly above the point where storm water enters.

Ms. Kulakow asked that R1 and R2 be defined. They are existing monitoring stations for the City of Woodland. R1 is 800 feet above the City point of discharge near the City property line. R2 is approximately 1800 feet downstream of the discharge.

Ms. Kulakow said that the Dixon Resource Conservation District drains water into the Bypass and that perhaps there should be a monitoring site near that discharge. The difficulty of monitoring in a tidal zone was discussed.

There was further discussion of appropriate sites and timing.

Monitoring Frequency

Monthly monitoring is preferred, according to Mr. Ruby, so as to capture annual variation. The CALFED grant scope includes quarterly monitoring for one year.

Should volunteers be used to monitor? Additional sites could be monitored if volunteers participate. Training can be provided and quality control can be handled in essentially the same way as with paid sampling staff. Possible sources of volunteers are the Riparian Improvement Organization (RIO), Yolo Basin Foundation, Cache Creek Conservancy, and Putah Creek Council.

Mr. Ruby will look at what monitoring others are doing in the Bypass to see if there is a way to coordinate collection times and constituents being monitored.

A participant asked if the most cost is in the field collection or in the analysis? The analysis is the most expensive step.

The meeting was adjourned at 1:30 PM. The next meeting will be scheduled in a few months.

Appendix 1-B.

YOLO BYPASS WATER QUALITY PLANNING PROJECT
CalFed Grant # WSP01-FP-0073

STAKEHOLDER GROUP MEETING #2

Wednesday, October 15, 2003
10:30 AM – 1:00 PM

CA Dept. of Fish and Game, Yolo Wildlife Area Headquarters
45211 County Road 32B, Davis

IN ATTENDANCE:

Doug Baxter, City of Woodland
Chuck Dudley, Dudley Ag
Christine Engel, City of Woodland
Chris Erichsen, LWA
Mike Hardesty, Reclamation District 2068
Marianne Kirkland, California Department of Water Resources, Division of Environmental Services
Kathryn Kuivila, US Geological Service
Robin Kulakow, Yolo Basin Foundation (YBF)
Rick Landon, Yolo County Agriculture
Rich Marovich, Lower Putah Creek Coordinating Committee
David Phillips, UC Davis
Paul Robins, Yolo County Resource Conservation District
Armand Ruby, Larry Walker Associates (LWA)
Keith Smith, City of Davis
Casey Walsh Cady, Calif. Department of Food & Ag
Betty Yee, Regional Water Quality Control Board - Central Valley

I. Introductions

II. Project Progress and Overview

This is the 2nd Stakeholder meeting. At this point the group needs to agree on a list of pollutants of concern, what will be monitored, and where the monitoring sites will be located.

LWA and Chuck Dudley have been looking at the hydrology of the Bypass.

LWA will be directing some volunteers to take some measurements in the Bypass as part of World Water Monitoring Day to be held in November.

The project completions date goal to give the California Bay Delta Authority (CBDA) a report by June 2005.

The goal of the project is the production of a comprehensive plan for improvement of water quality within the Yolo Bypass. This plan will account for the diverse interests in and uses of the Bypass, and will aim to make the best and most reasonable use of funds available for that purpose.

III. Yolo Bypass Water Quality Issues

a. Land Uses, Pollutant Sources, Beneficial Uses

The main drive for this project is the State Water Quality Section 303D list. This list comes out of the state and then it is approved by EPA. By reviewing the 303d list we will see what the state deems to be most important. The list is organized by watershed segment. We are interested in the lower reach of Cache Creek, Putah Creek, the Delta waterways, and the Yolo Bypass.

The contaminants listed include:

Cache Creek: Mercury. This is a legacy pollutant. The specific source has not been determined

Putah Creek: Mercury. It source is from historic mining.

Sacramento River from Knights Landing to the Delta: Diazinon. The limits are derived from data from Department of Fish and Game. Diazinon is the.hottest issue in urban runoff. It is used as a dormant spray for orchards. This can be beneficial from a water quality standpoint. There are no leaves, so less spray is needed. However, it also coincides with heaviest rainfall and runoff season. A reason for modifying the Sacramento River Basin plan is to modify controls on orchard runoff. EPA has banned most residential and commercial use in recognition of the runoff issue.

There are 2 sets of evidence: storm water runoff levels and identification in the Sacramento River Basin. Programs are in place to move this board issue in the next few years. Organophosphate pesticides and mercury most of most concern but programs are in place that will control them so we may not need to worry about them as much?

Mines are a big source of Mercury. This is from the extraction of mercury itself, Its principle use was in gold extraction as an amalgeman.

Betty: She commented on the total maximum daily load (tmdl) implementation plan. It identifies tmdls. Purpose is to limit pollutants to a tolerable level. We can only accept x amount in each water way. To achieve tmdl, orchardists have to implement some steps. This is already developed by growers. They will have to produce a workplan for the regional board This project needs to keep tmdls in mind when designing a monitoring plan.

303d lists are a work in process.

Organophosphates: diazanon and chloropyrifins
Contributors include urban runoff from the Cities of Davis and Woodland, and UC Davis. This includes the discharge from 3 water pollutions control plants. At this time urban run off of organophosphates exceeds DFG limits.

DDT was banned many years ago so why is it still on the list? Dde and ddb (??) are breakdown products of DDT. In 2002 there was an increase in DDT warnings. It's a legacy pollutant. It is present in sediments.

Difference between organophosphates.and chloropyrifrins:

Organophosphates photo degrade. They persist in the environment for 3-4 days. Sediments don't contain a lot.

DDT and others persist in sediments. They are brought back to the water column when sediment is stirred up during runoff from storms. Breakdown in ph7 (??) conditions.was banned in the last 20 years.

Area treatment plants aren't showing signs of pesticide runoff.

The group reviewed the 303d list of water quality limits for concerning the Yolo Bypass.

There are two concerns in this area: conductivity/dissolved solids and new bacteria standards. This all means more treatment will be required in the future. Ag needs low conductivity. This mainly relates to growing strawberries.

Woodland plant: electrical conductivity levels are exceeded when ground water is pumped. To meet the required levels the treatment plants would need do reverse osmosis. People can drink the pumped groundwater but it can't discharge into the sloughs. Here agriculture currently uses groundwater that is already high in electrical conductivity. It would cost an estimated $40 million to start reverse osmosis in area treatment plants.

In the area, we are regulated by the Sacramento River Basin Plan. There is a set of beneficial uses compiled in the handout distributed at the meeting.

Review of 303d list of beneficial uses concerning the Yolo Bypass:

(Asked to describe freshwaterhabitat – potitntial. Why is it potential.means reg bd determined there is a potential for freshwater habtita – cold – didn't actually see fishusing this type habitat but it is available) ???

Domestic water supply is not listed for the Yolo Bypass. Recently the EPA determined that all areas serve as domestic supply. So the group must consider levels anyways.

Yolo Bypass drains into the largest drinking supply in the state—the San Francisco Bay delta. So this project must consider domestic supply. This distinction means there is a whole list of conditions to meet.

b. Historical water monitoring data:

Willow Slough Bypass, Tule Canal, and Putah Creek undergo regular monitoring by treatment plants. State requires intensive monitoring for treatment plants. This monitoring focuses more on toxics. Mercury and organophosphates are covered by California toxics rules.

UC Davis treatment plant does find toxics in its water monitoring. Upstream has it. This goes for Woodland and Davis too. Metals are detected routinely. X metals not found except very sporadically and are never found in pesticides. ???

Woodland found mercury and organophosphate pesticides each time it monitors both upstream and downstream.

Bistec is ubiquitous in the environment. It is found in product of plastics. Not found upstream and downstream of Woodland plant. Why is it found upstream of the treatment plant. It is a plasticizer used in the formation of flexible plastics. Cups, bags, and candy wrappers contain it. PVC doesn't have bistec2 because it is found more in flexible plastics. It is hard to get rid of it.

Lindane is occasionally found in Woodland but has not been detected for years. Over the counter lindane is banned.

No berylium has been found.

NAWQA is a federal program. It has excellent data. The group is fortunate to have a NAWQA monitoring site in the Bypass.. The project will include their data in database. The haven't analyzed which are above water quality objectives.

C. Seasonal Hydrology .

Chuck Dudley looked around the Bypass at seasonal use of water. Use is very seasonal. His analysis started with Oct. – Ag use is slowing down, Hunters are flooding wetlands up.

Most of the year the Bypass is a net water user. A lot of water is used in Bypass. Davis, and UC Davis treated water is used in the Bypass. There are 3 pumps north of Putah Creek and south of I-80 that use a lot of water.

Mid summer is the only time of stable water use. Chuck did the analysis for a 1-year period. There is a dry period in late spring and early fall where there is no storm runoff or ag runoff

Rich asked when the first runoff event usually occurs.

When the Colusa Basin is draining could it over run the ridge cut and cause run off in Bypass?

IV. Identification of Pollutants of concern issue

The Calfed proposal has a preliminary list of POCs – The group reviewed the Yolo Bypass Proposed Sampling and Analysis Option handout. This formed the basis for the project budget. It assumed that there would be four sites for x??? years. Since the project began additional constituents have been added to the POC list for the Yolo Bypass Watershed Management Plan matrix. The group reviewed the matrix handout.

The project must monitor for those listed on the 303d list. There are some historical artifacts on the proposal list including cyanide. UC Davis has detected it very occasionally. Less of artifact than tributylin. That is a questionable parameter, --no one detects it any more.

The first two have been dropped from UC Davis list. They can be dropped from the project list.

If Bis2 sampled for you will get a lot of other stuff along with it.

Organophosphate pesticides have not found

The project team has a new list into Calfed for review. Calfed must approve it before any POCs be added or deleted. Bis2 limits have not been exceeded at UC Davis. The City of Davis occasionally does

Betty: should we delete Bis2 from the list? David Phillips, the UC Davis representative concurred saying that it is not that much of an issue. That would save project a lot of money also.

EPA 625 scan samples for ??? If the listed 3 are not an issue, take them off the list.

Christine: What would be the benefit of keeping them on? Could maybe learn more about distribution. It is everywhere so it is hard to get meaningful data. Even labs have a hard time keeping it out of lab equipment. It is doubtful that it would add to the knowledge base. It may be an endocrine disruptor. Many things are.

Betty: wait to do 625 scan after more studies and a problem has been identified.

David: He suggested taking off it off the list. It would save money, so project can be more focused—monitor more sites and more frequently.

Three species chronic toxicity testing will catch pollutants that are of concern for wildlife health.

Armand asked if there is consensus about taking hexachlorobutadiene, and Bis2 off the list. Yes

Is there orchard runoff in the Bypass -yes—Cache Creek, Colusa Basin, and Willow Slough. There is some minor use of diazinon on row crops. Have to keep organophosphate pesticides on the list due to urban runoff. Diazinon used very seldomly on alfalfa.

Consensus to keep organophophates on the list

Chlorinated pesticides – should we keep them on list?

Betty- can you do a one-time sediment analysis instead of monitoring for it on a regular basis. If oc’s found then design a project around it

Rick: probably not in water column just sediments.

Question on carbamates. They are not on the op list. County screens for chlorinated pesticides and organohosphates.

One option is to substitute carbmamates for chlorinated pesticides. That would give up ability to test for DDT.

Sediment test is only done once.

David – it is a site specific test. It wouldn’t give information on whole the Bypass.

It would be hard to take oc’s off the list.

Thiodan still in use, It is an chlorinated pesticide.

Should carbamates be on list?
Should Carbaryl be on list? It is used in rice when there are infestations such as army worms.

If the project is not doing a 325 test then they test for carbamates. That would be a suitable trade. They have urban and ag uses so its found in runoff. It is used in snail pellets. It would be useful data for urban treatment plans.

Consensus was that the carbamates via EPA 632 will be added

Should we test for mercury? Testing could show something about the distribution of it in the Bypass. Does water spilling over the weir add it to the Bypass? Is it found above the Knights Landing ridge cut? It is definitely in the Tule Canal.

Are there management implications if mercury is present?

There are issues on the Sacramento River Watershed scale. Data could support closing of mines.

Methyl mercury testing: Would need to look at the water column. Fish tissue contains good data on methyl mercury. But fish move around. First need to know where it is in the Bypass and then do a fish tissue analysis as a good follow-up. Distribution data would be helpful for future studies.

Is it known which contributes more mercury Cache Creek or Putah Creek? That will be known in one year.

LUNCH

Metals – chromium – take off list?

UC Davis: Aluminum, copper, chromium 6 are all of concern, beryllium is not

City of Davis: Keep aluminum on –natural treatment has contact with soil, keep selenium on.

Chuck – Ag concerned with copper

UC Davis– iron is an emerging issue.

Agreed to switch iron with beryllium, will test for total chromium. Not III???

Will use total chromium as a screening tool to see how much total chromium is out there. Chromium 6 is more expensive to test for.

Chuck: Is color part of the ag waiver requirements?

Rick – yes

Add boron to list.

Color test not expensive.

Christine: Additional tests dependent on Calfed and additional money from City of Woodland

Higher hardness of water – metals less available, better for fish

TDS – total dissolved solids, changes seasonally quite a bit.

Consensus is to add TDS to list.

Boron – is issue to City of Woodland. Is it to Davis or UC Davis? Is it in the drinking water?

Woodland is close to the need for action level. It is advisable to keep it on the list

Betty: There are high levels of boron in Cache Creek.

Keith Smith – levels of boron in water varies with depth of aquifer, mid levels tend to have highest.

Consensus is to add boron to the list.

Nitrate – It is necessary to monitor it for the ag waiver. It is a drinking water issue.

Betty: Nutrient levels depend on more than nitrate.

Could use it as an indicator.

Delete tributyltin and cyanide.

TOC – analogous to color test – It is a good indicator of total organic carbon. This is an ag waiver issue and a drinking water issue.

TSS - Keep on the list. It is a standard water quality indicator.

E coli – changed from fecal choloform. The new levels focus on e coli.

3-species chronic toxicity – This will catch toxic effects of several factors. The three species are : Fathead minnow, cerriodaphia (water flea), an an algae (selanstrom.)

(I left the meeting here)

V. Monitoring Program Planning

Site Selection

Monitoring Frequency
Analytical Constituents
Inclusion of Volunteer Monitors
Schedule

VI. Plan and Schedule Next Meeting

Appendix 1-C.

YOLO BYPASS WATER QUALITY PLANNING PROJECT
CALFED Grant # WSP01-FP-0073

STAKEHOLDER GROUP MEETING #3
MEETING MINUTES

MEETING DATE: JUNE 22, 2004

LOCATION:	Larry Walker Associates 707 4th Street, Suite 200 Davis, CA 95616
IN ATTENDANCE:	Robin Kulakow, Yolo Basin Foundation (YBF) Dave Feliz, California Department of Fish & Game Armand Ruby, Larry Walker Associates (LWA) Chuck Dudley, Dudley Associates Keith Smith, City of Davis Dawn Lindstrom, Putah Creek Council Chris Erichsen, LWA Christine Engel, City of Woodland Marianne Kirkland, DWR Ted Sommer, DWR Casey Walsh Cady, Calif. Department of Food & Ag Betty Yee, Regional Water Quality Control Board Jim Beatty, City of Davis Doug Baxter, City of Woodland David Phillips, University of California, Davis Janna Harren, California Department of Fish & Game John Curry, Resource Conservation Service, Dixon Rollie Baxter, City of Woodland
***NEXT MEETING*:**	To be scheduled in August 2004.

ACTION ITEMS:

1. Armand and Robin will coordinate August meeting and agenda.
2. Chris Erichsen to send POTW mercury effluent limits to Marianne Kirkland.

INTRODUCTIONS

Armand Ruby called the meeting to order and began introductions of attendees.

PROJECT OVERVIEW

Armand Ruby reviewed the project goal, objectives and approach.

Chris Erichsen summarized the Yolo Bypass monitoring data to date.

Jim Beatty: The City of Davis will soon begin collecting data on methyl mercury upstream of effluent discharge (on Willow Slough Bypass). The City would share this data with the stakeholder group.

Betty Yee: Delta Mercury TMDL will assign loads to mercury inputs, including Yolo Bypass. Plan will be available later this summer.

Marianne Kirkland: What are mercury limits in treatment plant effluents?

Armand Ruby: We will get this information to you.

Marianne Kirkland: Will the Yolo Bypass sampling program be extended?

Casey Walsh-Cady: Depends on funding source.

Christine Engel: Project deadline is June, 2005. When final report is delivered to Woodland, then it may be possible to look at further funding opportunities.

Armand Ruby: Yes. We will complete the project on schedule, then assess next steps.

PRESENTATIONS FROM STAKEHOLDERS

PRESENTATION #1

Davis Phillips, UC Davis, presented issues and an update on the University's compliance with EC effluent objectives.

The real EC problem is the Regional Board's approach to EC rather than EC itself.

1. UCD can not comply with either of Regional Boards' EC limits:
    a. 700 umhos/cm, intended to protect agricultural uses
    b. 900 umhos/cm intended to protect drinking water
2. UCD operates an advanced (tertiary) treatment plant (circa 2000), discharges 2.5 MGD (million gallons per day) and has ultraviolet disinfection; new EC limits would

require reverse osmosis (R.O.) at substantial capital and annual operating costs – plus issues with energy use and brine disposal

3. Effluent discharges west of Old Davis Road into Putah Creek
4. Overview of historic EC values in local waters
5. Most EC comes from campus' deep aquifer domestic water supply
6. Basis for 700 umhos/cm comes from United Nations crop study
7. UCD is working on establishing a localized EC recommendation based on local modeling and crop assessment study by UCD Prof. Stephen Grattan; study is due to Regional Board in July
8. The UN study is not suitable everywhere, including Putah Creek ag uses
9. There are no salt sensitive crops, mostly grain, corn, and tomatoes
10. Precip. Annually flushes salts from the Bypass, even without flooding
11. EC compliance will cost millions, the EC model will be used to compare costs with benefit
12. 900 umhos/cm is in NPDES permit and is being appealed to State Board. 900 is based on Title 22 drinking water standards.
13. City of Davis drinking water quality is higher in EC than UC Davis permit limit.

Armand Ruby: How would you deal with the brine if you have to go with R.O.?

Dave Phillips: Deep well injection.

Jim Beatty: What is cost of drilling one well?

Dave Phillips: Million dollar range.

Chuck Dudley: Would you model EC seasonally?

Dave Phillips: Possibly.

Casey Walsh-Cady: Are there wildlife considerations with EC?

Dave Phillips: Wildlife issues are not driving EC limits.

Casey Walsh-Cady: Is it feasible to ask growers to not grow beans?

Dave Phillips: Considered it, but felt it was too complex.

Dave Phillips: With other issues (perchlorate in milk), so much energy spent on EC is wasteful.

PRESENTATION #2

Dave Feliz, CA DF&G presented wetland management and restoration issues.

1. Yolo Bypass Wildlife Area covers 16,000 acres; Currently scoping for consultant to work on preparation of wetland management plan EIR

2. Trying to deal with methyl mercury / wetland restoration issues
3. Not much information on methyl mercury in source waters (trapped tidal waters)
4. On Refuge, organic tomatoes and wild rice are grown, some rotation with white rice (non-organic)
5. Would like to keep Knights Landing Ridge Cut as permanently flowing water supply to Bypass (rather than divert to Sacramento R.)

Armand Ruby: What is the management plan's overriding goal?

Dave Feliz: To manage and restore wetlands, as well as generate operating income and understand how much of a problem methyl mercury is.

Armand Ruby: Would you maintain ag uses to support operating costs?

Dave Feliz: That remains to be determined.

Armand Ruby: So the water quality issues on the Refuge are: possible methyl mercury generation in wetlands. Ag side – EC effects, generation of pollutants (e.g. pesticides)?

Dave Feliz: Yes.

PRESENTATION #3

John Curry, Dixon RCD, presented information on agricultural users' issues

1. Ag waiver is important issue that requires preparation and understanding of issues, esp. those related to monitoring
2. Big question: what is ag contributing to water quality issues?

Armand Ruby: Are there any EC-related issues that you are aware of locally in the ag community?

John Curry: Have not heard any concerns.

Armand Ruby: What are ag community's concerns?

John Curry: What leaves their property, BMPs, pesticides, TOC, TSS, toxicity.

Rollie Baxter: It would be a good to share data, especially EC.

John Curry: Yes. Ag waiver can be demanding, so data sharing is critical.

PRESENTATION #4

Ted Sommer, CA DWR, Environmental Services Division

1. Brief overview of activities – functionally for DWR Bypass mainly serves flood control purpose
2. But DWR also supports other uses; some funding from CalFed for restoration-related activities
3. DWR supports restoration efforts in Yolo Bypass through pre-project monitoring, studies to understand aquatic wildlife
4. Hydrology in Bypass is roughly known
5. Discussion of aerial photography and Bypass inundation modeling
6. Other work includes biological studies (food web, migratory fish), water quality (mercury, pesticides, based in lower Bypass) – including effects of wetlands restoration on methyl mercury generation, sediment
7. Happy to share data

Armand Ruby: Future plans?

Ted Sommer: Working with Dave Feliz on wetland restoration, lower Putah Creek restoration opportunities (historic creek meander). Also Conaway Ranch acquisition and possible restoration of fish passage to Cache Creek; Fremont Weir upgrade and seasonal connection to Tule Canal. Restoring native/riparian vegetation.

Rollie Baxter: Is Yolo Bypass basin a mercury trap?

Ted Sommer: Yes, the Bypass is overall a depositional zone. For migrating species it does not appear to pose a threat or problem due to seasonal use, as opposed to year-round habitat.

Dave Feliz: In Bypass, wetlands are only seasonally inundated.

PRESENTATION #5

Betty Yee, Regional Water Quality Control Board, Central Valley (Region 5)

1. Discussion of mercury concerns on Regional Board as they pertain to Bypass – loads to be defined in draft Delta Mercury TMDL. Cache Creek and Yolo Bypass are big mercury load contributors.
2. Rice pesticides in Colusa Drain
3. Regional Board is to meet on Ag Waiver to discuss satisfaction with submitted monitoring plans / proposals.
4. Pesticide / Toxicity problems: specifics unknown, monitoring to characterize local inputs
5. Salt Loads – more than just localized usage. May be of interest to UCD.
6. Larger Problem: Drinking water in Delta – Policy formation in progress.
7. Effluent-dominated water bodies are not clearly defined, high priority in Basin Plan

Rollie Baxter: How are load reductions defined in TMDL?

Betty Yee: Undefined as of yet, but something like 50% of load comes from Cache Creek, 10% from Putah Creek, rest is unquantifiable (may be Ridge Cut and Sacramento River)

Marianne Kirkland: Some DF&G work will help quantify relationships between wetlands and methyl mercury production (Chris Foe, Mark Stephenson) is in progress.

Dave Feliz: Is the methylation – wetlands connection derived on Delta work?

Betty Yee: Not all. Also from studies in eastern states.

Casey Walsh-Cady: Are salt loads an issue for drinking water?

Betty Yee: Drinking water policy is in development, due in 2011.

Armand Ruby: Typically, when a new project changes salt/EC levels in the Delta, the big water purveyors, who are stakeholders, get involved in assessing impacts.

PRESENTATION #6

Rollie Baxter, City of Woodland

1. Woodland shares EC issues with UC Davis
2. Currently serves 50,000 people at 6.8 MGD (permitted at 7.8 MGD), to expand to 10.8 MGD
3. High quality effluent
4. Permit requires tertiary treatment although no scientific reason supports this move
5. EC and Boron are plaguing issues
6. Recently appealed NPDES permit on EC, new permit issued, no new EC limit until 2 year study is complete
7. Currently evaluating alternatives (not Reverse Osmosis) to meet low EC levels: land application, new river discharge (north to Sacramento R. near Feather R., or south to Sac Regional)
8. Possible new water supply source (Sacramento R.?) could help
9. Conaway Ranch acquisition could provide source or river water

Armand Ruby: Is that entitlement sufficient to supply city's needs?

Response: More than enough.

Marianne Kirkland: Is groundwater discharge an alternative?

Rollie Baxter: It may be.

PRESENTATION #7

Keith Smith, City of Davis

1. Davis shares EC issues with UC Davis and Woodland
2. Currently serves 65,000 people at about 6 MGD
3. Restoration of wetlands important part of future planning
4. Ammonia occasional problem in effluent
5. Aluminum effluent limit to be at 68 in new permit – derived mostly from local clay soils/groundwater supply
6. Bacteria limits also problematic due to high detention times in ponds/wetlands
7. Acquisition of Conaway Ranch by local agencies is a big topic
8. City's options: continue discharge to effluent-dominated waterway; cooperate with Woodland on possible discharge to Sacramento R.; possible discharge to surface waters (land disposal); acquire better quality water supply; impose source controls
9. Not looking seriously at coagulation/filtration or reverse osmosis

Discussion ensued about the Conaway Ranch acquisition, JPA, etc.

ASSIMILATION OF ISSUES

Armand Ruby reviewed the big issues presented and linked them with their sources and regulatory drivers:
=================

EC: POTW effluents and source water
- *Regulatory: Title 22 (900 umhos), Secondary drinking water standards; Ag uses (700 umhos)*
- *Downstream drinking water sources (Delta)*

Boron: POTW effluents and source water (groundwater)

Mercury, esp. transformation to methyl mercury
- *Restoration of wetlands*
- *Delta TMDL (in process)*

Selenium/Aluminum: POTW effluents, source water

Pesticides: Per ag waiver monitoring program, etc.

Flow/Supply of water for irrigation, wetlands supply - related to POTW issues, options that would reduce discharges to Bypass

Organic Carbon: phytoplankton – need more for fisheries, less for water supply

Watershed-wide solutions; Receiving water context

=================

Dave Phillips: Yolo Bypass does not have MUN (Municipal Supply) as Beneficial User so drinking water standards do not apply.

Betty Yee: Tributary Rule does not apply to Yolo Bypass, as it is not a named tributary, which is different than "protecting downstream Beneficial Uses". However, drinking water policy may well apply.

Marianne Kirkland: Some fishing and swimming does occur in Bypass.

Armand Ruby: Actual Beneficial Uses should be protected. EC is a regulatory issue. Ongoing studies are needed to shed light on real ag impact from EC (UCD modeling).

Keith Smith: Rec 1 (water contact beneficial uses) is interesting; considered possible; so Title 22 is law.

Marianne Kirkland: Is there a methyl mercury limit?

Armand Ruby: No, not in the CTR.

Keith Smith: Proposed Delta Mercury TMDL sets 5 ng/l for Methyl mercury.

Rollie Baxter: If wetlands treat water low in mercury, then there are obvious wetland benefits, but if water is high in mercury, then is the source ambient?

Armand Ruby: Sources of mercury are transport of sediments, etc.

Dawn Lindstrom: Are there plants that can "bioremediate" mercury?

Armand Ruby: Not known offhand but worth looking into.

WRAP-UP

Armand Ruby: This project provides an opportunity to think outside of the every-day regulatory framework, and as a group envision cooperative solutions that would best serve the interests of the public and local stakeholders. We are charged with developing an integrated water quality management plan for the Bypass, and together we should take advantage of this opportunity to develop a plan that we think is workable and really makes sense.

Meeting was adjourned; to reconvene in August.

Appendix 1-D.

Draft Minutes

YOLO BYPASS WATER QUALITY PLANNING PROJECT
CalFed Grant #WSP01-FP-0073

STAKEHOLDER ADVISORY GROUP MEETING #4

Friday Dec. 3, 2004
10:30 a.m. to 1:30 p.m.
Larry Walker Associates
727 4th Street
Davis, California

Attendees: Armand Ruby, Armand Ruby Consulting
Keith Smith, City of Davis,
Stephen McCord, LWA
Betty Yee, Regional Water Quality Control Board
Marianne Kirkland, Department of Water Resources (DWR)
Ted Sommer, DWR
B.G. Heiland, DWR
David Phillips, UC Davis
Casey Walsh Cady, Department of Food and Agriculture,
Rollie Baxter, City of Woodland
Chris Erichsen, Larry Walker Associates (LWA)
Tess Dunham, LWA
Christine Engel, City of Woodland, Public Works
Petrea Marchand, Yolo County, Planning Department
Robin Kulakow, Yolo Basin Foundation
Denise Sagaro, Yolo Farm Bureau

I. Introductions

II. Project Update

Refer to Gannt chart for project timeline and status. Monitoring was finished in October. Now the project team is looking at the feasibility of control measures and possibly site-specific objectives. The completion date has been moved to the end of April. The final report will go to CalFed then. A draft will be sent out to this group by March 18. There will be three weeks for comments from the Stakeholder group with a deadline of April 8. There will be time for only one more stakeholder meeting in February to focus on potential control measures. At that meeting the group will review a draft outline of the proposed management plan.

Budget for tasks 7, 8, 9 has some funds left. The monitoring budget is depleted as are earlier tasks. The project is keeping on schedule. Contract end date is June 30. CalFed wants final reports before end date.

III. Monitoring Summary: Activities and Results to Date

Chris reviewed the draft water chemistry and toxicity report for November 2003-2004. This Power-point presentation is available for review and can be sent out by email to interested parties.

A handout also was provided summarizing the results of the chemical analysis, field measurements, and toxicity tests. See handout for list of POC metals. There were 12 monitoring sites in the Yolo Bypass that were used for this study. They included the Ridge Cut, Cache Creek drainage, Putah Creek, Willow Slough, the ag drainage from the Colusa Basin Drain. One site was located in the Yolo Wildlife Area. The Fremont Weir and Sacramento Weir overflows were monitored during a Bypass flood event last year. Toxicity data was collected four times. Acute toxicity results from date were taken from the ag waiver program.

During December through January of last year the monitors couldn't access the toe drain. In February and March they couldn't get to the Wildlife Area. There were 12 sites, 12 events, one flood event, 4 toxicity events, 6 full suite events, 12 mercury and bacteria events. Some Riparian Improvement Organization volunteers helped collect samples.

The samples were reviewed for detectable POCs. A Table with POCs exceeding objectives (exceedances) was reviewed. There is some temporal variability in the tables. The data is ready for an internal review then it will go on to the QACC reviewers. Group may want to discuss objectives for those with no assigned objectives. The Regional Water Quality Control Board is still considering some objectives. It was acknowledged that additional funds from the City of Woodland and City of Davis were used for additional chemistry analysis and sediment toxicity testing.

No fathead minnow toxicity was observed in January samples.

Please do not consider the data as final. It is still being reviewed. Data are summarized by constituent and compared to water quality criteria or objectives.. This is meant to be an analysis to guide development of the management plan, not a regulatory compliance analysis. Besides the levels and comparisons to objectives, we also look at how often a constituent was detected. Metals generally were detected 100 %, with some variation.

Some things to consider:

How often does each constituent exceed the criterion? Aluminum (Al) is a common element in most soils. Boron abundance is similar. These are compared to drinking water criteria. There was a discussion of variation in lab analysis. The variations will be checked for final report. The Yolo Bypass is not designated MUN (municipal drinking water supply). There were a few hits for chromium with no particular pattern.

Mercury and methyl mercury presence and sources were discussed. Ted Sommer asked the group to consider that wetlands can create methyl mercury. Question: Is there the ability to ascertain an effect from the Yolo Wildlife Area on methyl mercury using the sample data? Answer: not really. The Wildlife Area sampling site is at the upper side of the set of pumps at the lift station on the cross canal that brings water in from the Toe Drain. The project was trying to characterize the source of water serving the Wildlife Area rather than the output from it. They looked at input rather than output. During flood events there will be some mercury transport. There would need to be more monitoring to determine output of methyl mercury from the Wildlife Area. There are studies being done on production and transport of methyl mercury.

A question was asked on how the mercury sediment data were collected. Generally, the top centimeter of sediment was carefully lifted up in an effort to sample the finer deposits. At the Wildlife Area site the monitors had to scrape the rocks to obtain sufficient sample, as the access was difficult.

Based on other studies it looks like more sediment comes over the Fremont Weir than from other sources. It is presumed that the Cache Creek Settling Basin is taking out some of the mercury. It's hard to say where the boost in mercury at Woodland test sites R1 and R2 is coming from. It's important in the report to note that sampling at Wildlife Area was for inputs not output since there is so much interest in Wildlife Area's effect on methyl mercury totals.

Total dissolved solids were high as a whole. Electrical conductivity was spotty. But there were a number of exceedances here as well. This number is important to the wastewater treatment plants. Petrea said that the County is interested in compiling all of the known water data. This project will do that during the time of the contract. The Willow Slough Bypass site is downstream from City of Davis treatment plant. The Putah Creek site is down stream of the UCD treatment plant. The idea was to choose one ag monitoring site. This was down south of Putah Creek in an ag canal known as the Z Drain.

Coliform was found everywhere. City of Davis coliform level high due to birds. Coliform levels are in some ways misapplied to sites beyond the treatment plants. This is not appropriate where there is a lot wildlife use. Wildlife Area levels would be higher if measuring after water was distributed to the ponds.

Total organic carbon . There is no Basin Plan standard so no criterion is applied. CalFed is finding that most of total organic carbon is coming from the Sacramento River rather than the Delta. There may be some organic carbon work going on in Yolo County with the Yolo Resource Conservation District.

Detected pesticides were very low. Only found DDE and chlorpyrifos above criteria levels at some sites. DDE is a breakdown product of DDT even though DDT has been banned for over 30 years. Wouldn't show up if it were not being used. They will need to look into sources of pesticides. There are no surprises in this data. There is some surprise with the low levels at Knights Landing Ridge Cut. There is a pulse in the summer from the rice fields. Most rice water needs to be held 30 days in the field to breakdown pesticides. Diuron is a broad level treatment pesticide including use on rice. Petrea asked about coordination with Colusa Basin Drain study. Ted commented that it does not appear that there are significant problems with the Colusa Basin Drain water.

Toxicity testing was added on to the data analysis. No toxicity was found for the most part. There was one hit on algae and none on Ceriodaphnia. Sediment toxicity analysis uses two organisms since they are susceptible to different toxins. One hit was noted at the Ridge Cut with Hyalella azteca. There were sediment toxicity hits at the Ridge Cut, Willow Slough, Tule Canal, and Toe Drain. The analysis process takes some of the sample, adds organisms, feeds them for a period of time. Then organisms are filtered out to determine survival and weight.

IV. Review of Water Quality Issues Raised by Stakeholders

Conductivity was a main issue for the POTWs. Levels of boron, bacteria, and aluminum secondary issues.

Department of Fish and Game, DWR, and the Regional Water Quality Control Board rank methyl mercury as main issue-wildlife/fish habitat, human health mercury in fish.

Next level of issues: pesticides, salts
Boron, selenium, organic carbon, aluminum – many exceedances throughout the Bypass.
Exceedances match the short list of issues pretty well.
 Methyl mercury – all exceedances
 Fecal coliform, e coli many exceedances

Everything is related to natural conditions except pesticides. Boron, aluminum are not related to anything controllable. Four years of sampling of Cache Creek Conservancy wetlands showed an increase in methyl mercury. Data is on Yolo County website/Planning public works/
Some research has been done on invertebrates/fish. No data is available on the effects on next level of food chain.

V. Overview of Next Steps:

Project steps:
1. Complete Monitoring- done;
2. Analyze Monitoring Data- underway
3. Evaluate Control Measure and management alternatives for Pollutants of Concern

4. Investigate Feasibility of Site-Specific Water Quality Objectives. Establishment of site specific standards is a possibility.

5. Develop Coordinated Water Quality Management Plan

The CalFed scope of work emphasizes development of a management plan for POCs. A draft report outline has been done. Participants will be asked to review the outline and get back to Tess and Armand with comments.

VI. Preliminary Discussion of Potential POC Control Measures

Keith Smith, City of Davis Engineer, commented on management alternatives. The City does not have an EC limit now. Source water, from groundwater wells, is already above control levels. The water is very hard. The majority of people use water softeners which adds to the EC also. Overland treatment (wetlands) used by the City. EC is above 3,000 (?) This is a high level for agriculture. But agriculture is still using the water for irrigation. Treatment at this level is not practical. Use of membranes and disposal of that waste is very expensive. Salinity treatment is necessary. The solution is to bring in surface water for the community. It will take many years to do the environmental studies and to get water rights if it is even possible. The effluent would not be able to meet standards for many years. The City is going to make an effort toward public education.

This study is looking at management options, best management practices since treatment is not practical. How much do water softeners contribute to the problem? We need to consider the source control options in the management plan. It's a public education issue once surface water is available. One possibility is the use the Exchange-take systems vs self salting canisters. Another possibility is work on grants to change softener methods.

Rollie Baxter, City of Woodland Engineer, reported that Woodland has the same problem as Davis. Woodland water intake is about 1500 EC and discharges at about 1500. Woodland has a more capital-intensive treatment system compared to Davis. There have not been complaints from farmers that they know of.

Farmers are aware of the quality of the water available to them. They have adapted to the situation by the types of crops they grow. Woodland is looking at a different point of discharge. One option is to discharge into the Sacramento River rather than the Bypass instead of investing in more treatment. Davis discharge is insignificant in terms of volume discharged into Bypass. Davis discharges into Willow Slough and it is ciphoned off almost immediately by farmers so it doesn't usually make it to the Bypass. The Farm Bureau says that Davis/Woodland discharge is an important source of irrigation water.

Dave Phillips, engineer with UCD, reported that UCD has looked at effects of EC from discharge on crop yields. An EC of 1100-1200 in UCD's summer discharges has no effect on crop yield. There could be different discharge levels by season. Dave doesn't think the management plan needs to make recommendations in terms of treatment to improve EC discharge levels.

Betty Yee was not aware of a discharge compliance point for the Bypass. Water purveyors want EC as low as possible. The management plan could propose relief on POTW requirements but delta water policy makers may not agree. The Sacramento Basin Plan and Delta Plan have compliance points. Most points have chloride compliance levels rather than EC. The biggest issue is providing enough bay outflow rather than agriculture use issues.

We need to check into Bay-Delta compliance issues for the final report. Regulatory relief for POTW discharges is one possible outcome for the management plan, especially regarding EC. It appears that there is not a significant ag issue here in terms of EC. Farm practices also increase EC. The move toward conserving water concentrates salts. There are ways to reduce salts in everyday water use.

The management plan should address activities to reduce salts in water, check into Bay Delta water quality compliance issues, and address mercury issues.

It was noted that the Yolo Flood Control District should be contacted regarding the ground water quality study data that they have.

Petrea Marchand, with Yolo County, reported that the County is working on an integrated Regional Water Quality Management Plan. The plan is due in 2007. All water entities will be involved. Proposition 50 applications need to be on regional level. The Yolo County Water Resources Association will be submitting an application.

Preliminary data show that the Bypass is a net user of water in the summer. Ted commented on the development of a water budget for the Bypass. North of I-80 is one system. South of I-80 is mostly tidal water from the Sacramento River with some Putah Creek water. DWR is doing a study on water use in the Bypass. If you want more information on the study contact Marianne Kirkland.

Ted Sommer noted that the Yolo Bypass Working Group will be having a specific workshop on mercury issues in the Bypass.

VII. Discussion of Potential Project Follow-on Activities

Should a project of this type be continued in the future and if so with what funding?

Participants will be asked to comment on the report outline.

VIII. Plan, Schedule Next Meeting

The Stakeholders Group will meet again in early February. This will be the final meeting for the Group.

APPENDIX 2. DRAFT HYDROLOGIC TIMELINE FOR THE YOLO BYPASS

Draft Yolo Bypass Hydrologic Timeline

Courtesy of Chuck Dudley

October

Upper (North of I-80)

- Principal water utilization would be the flooding and maintenance of duck clubs, wildlife habitat, and (rice) straw decomposition.
- Rice field drainage would have been concluded in Sept. and some of drain water would still be in Colusa Basin drain and Ridge Cut early in the month.
- Flows in the Tule Canal would be composed of some Ridge Cut water, some drain water from irrigation activities to support duck club/wildlife/straw, effluent from Woodland/Davis, and some storm water from Woodland/Davis (depending upon rainfall amount). Cache Creek is essentially dry.
- Reclamation Districts on east side of Bypass would not be flow contributors at this time.
- Duck clubs get water from Knights Landing Ridge Cut and Sacramento River. Conaway gets water from Sacramento River through Reclamation District 2035 pump/pipe near I-5 area.
- Willow Slough Bypass diversion is removed. Flow, if any, goes to the Bypass.
- Crop harvest is completed.

Transition area (I-80 to Putah Creek)

- Principal water utilization would be the flooding and maintenance of duck clubs, wildlife habitat, and straw decomposition.
- Probably a small net flow from north, under I-80 (approx north end of tidal influence).
- North pumps for California Department of Fish & Game (CDFG) refuge would utilize the flow and probably some tidal from south to feed duck club/habitat/straw decomposition (late September to early March).
- The *tidal interface*, the most upstream influence of estuarine, tidal waters, is near the northern CDFG ‘low-lift’ pumps.

Southern Zone (south of Putah Creek)

- Principal water utilization would be the flooding and maintenance of duck clubs, wildlife habitat, and straw decomposition.
- Water source in the zone would be principally tidal flow from the Delta, UCD wastewater effluent, and Putah Creek ‘conservation release’.
- Significant amount of Toe Drain waters are pumped in this area by duck clubs.

November

Upper (North of I-80)

- Principal water utilization would be the flooding and maintenance of duck clubs, wildlife habitat, and straw decomposition.
- Gradual transition of flow starts to occur with onset of rainy season.
- Water source in normal years would remain nearly the same with an addition of storm water from the City of Woodland and a portion of northern West Sacramento.

Transition

- Principal water utilization would be the flooding and maintenance of duck clubs, wildlife habitat, and straw decomposition.
- Probably a small net flow from the north would increase slightly under I-80 (approximately the north end of tidal influence) due to increased rain and storm drain runoff.
- North pumps for CDFG refuge would utilize the flow and probable some tidal from south to feed duck club/habitat/straw decomposition.
- CDFG opens barrier on Putah Creek for migratory fish passage.
- The tidal interface is nearly stationary from October.

Southern Zone

- Principal water utilization would be the flooding and maintenance of duck clubs, wildlife habitat, and straw decomposition.
- Water source in the zone would be principally tidal flow from Delta and UCD wastewater effluent and Putah Creek ‘conservation release’.
- Significant amt of Toe Drain water are pumped in this area by duck clubs.

December

Upper (North of I-80)

- Principal water utilization would be the flooding and maintenance of duck clubs, wildlife habitat, and straw decomposition.
- Assuming some significant rainfall, bypass flows would increase with water from Cache Creek, Willow Slough, east side Reclamation Districts (from field drainage), and northern West Sacramento storm drain, Davis and Woodland storm drain.
- Duck club/habitat/straw decomposition water is from Ridge Cut, Sacramento River, and Cache Creek.
- Fields in the Bypass start draining into Tule Canal.

Transition zone

- Principal water utilization would be the flooding and maintenance of duck clubs, wildlife habitat, and straw decomposition.
- Increased flow from north moves influence of tidal water south. More of Fazio (CDFG) refuge water would come from the north through Tule Canal.

- The tidal interface is moved south by an increased volume of water from the north.

Southern Zone

- Principal water utilization would be the flooding and maintenance of duck clubs, wildlife habitat, and straw decomposition.
- Some drain water from agricultural areas of Solano County via complex east-west drainage canals that drain into Bypass.
- Significant amt of Toe Drain water are pumped in this area by duck clubs.

January

Upper (North of I-80)

- Principal water utilization would be the flooding and maintenance of duck clubs, wildlife habitat, and straw decomposition.
- Assuming significant rains, all tributaries to bypass have increased to significant flows.
- Duck club/habitat/straw decomposition water is from Ridge Cut, and Cache Creek.

Transition zone & Southern zone

- Principal water utilization would be the flooding and maintenance of duck clubs, wildlife habitat, and straw decomposition.
- Flow in Bypass is distinctly north to south.
- Water source through system is from north and not from Delta.
- The tidal interface could be removed from the Bypass during periods of heavy flow.

February

Upper (North of I-80)

- Water utilized is decreasing.
- Some duck clubs are drained. Straw decomposition activities are concluded.
- Water flow patterns remain much the same as Jan with all tributaries contributing to Bypass flow.

Transition zone & Southern zone

- Water utilization is decreasing.
- Some duck clubs are drained. Straw decomposition activities are concluded.
- Water flow patterns remain much the same as Jan with all tributaries contributing to Bypass flow.
- The tidal interface moves northward as flow from the north decreases.

March

Upper (North of I-80)

- Water utilization significantly decreases as habitat for waterfowl is reduced to brood pond habitat.
- As rains lessen, runoff decreases.

Transition zone & Southern zone

- Water utilization significantly decreases as habitat for waterfowl is reduced to brood pond habitat.
- As rains lessen, runoff decreases.
- The tidal interface remains south of its summer location because of Bypass flow and low water utilization.
- Yolo Basin Wildlife Area season flooding ends.

April

Upper (North of I-80)

- Water utilization is limited to waterfowl brood ponds.
- Winter flows decrease to insignificant levels from all tributaries. Still some input from Cache Creek.
- Farm work begins, land is dry enough to begin soil preparation, and crops are planted.
- Davis and Woodland treatment plant outfalls become a significant percentage of the water in the system.

Transition zone & Southern zone

- Water utilization is decreasing.
- Flow from north is limited and effluent based.
- Farm work begin, soil is prepared, crops are planted.
- Irrigation water utilized outside the Bypass is pumped from the Toe Drain.
- The tidal interface continues to shift northward.

May / June / July / August

Upper (North of I-80)

- Water utilized is primarily for crop production.
- Drain water from Ridge Cut, Bypass farming, east side Reclamation Districts, Willow Slough, all contribute to the Bypass flow.
- Most effluent is utilized north of I-80.

- Most drain water from the Clear Lake system (‘Yolo County Flood Control and Conservation District’) is diverted to the Conway irrigation system.
- Woodland storm drain is diverted into the Conway irrigation system.
- Conway irrigation system is closed and does not drain until September.
- Remaining flow in Cache Creek, if any, is diverted into the Conway irrigation system.

Transition Zone

- Water utilized for crop production and some wildlife activities on the Yolo Basin Wildlife Area .
- Irrigation season pattern is established with most of the water utilized in this zone coming from the Delta.
- Flow from Putah Creek is utilized by CDFG (Yolo Basin Wildlife Area).
- Balance of effluent is utilized in this zone.
- The tidal interface is near the northern CDFG ‘low-lift’ pumps.

Southern Zone

- Delta water dominated.
- Primary water utilized is for crop production and pasture.
- Some drain water reaches the Toe Drain from the west.

September

Upper (North of I-80)

- Water utilized for irrigation ends.
- Water utilized for duck clubs/habitat begins.
- Rice field drainage is significant part of Bypass flow.
- Conway irrigation system is opened to drain rice field water.
- After rice field draining, irrigation districts and reclamation districts contribute little water to the flow in the Bypass.

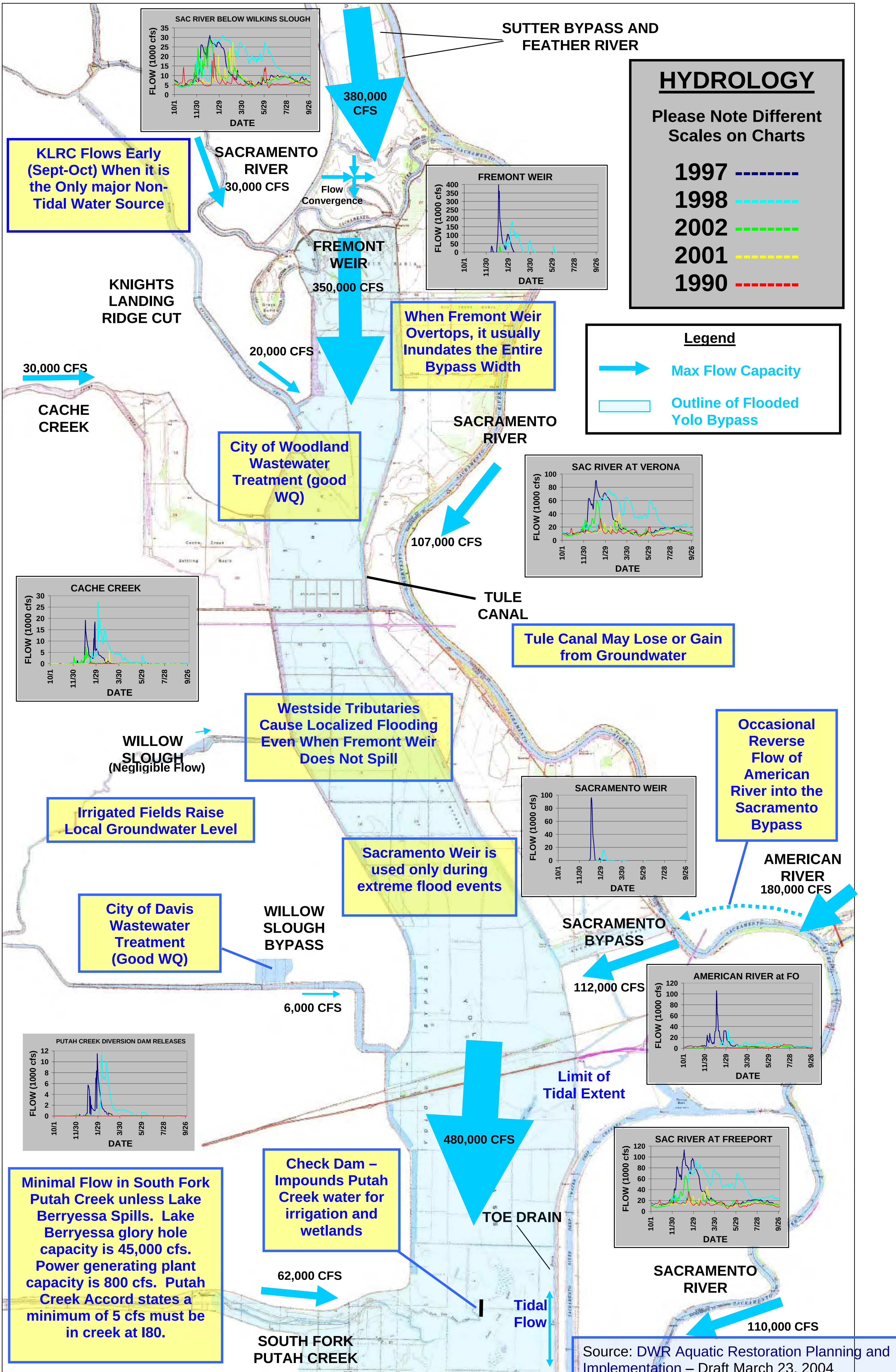
Transition Zone

- Water utilized for irrigation ends.
- Water utilized for duck clubs/habitat begins.
- Rice field drainage is significant part of Bypass flow.
- Effluent north of Putah Creek is utilized by CDFG at Yolo Basin Wildlife Area.
- The tidal interface remains near its summer point.

Southern Zone

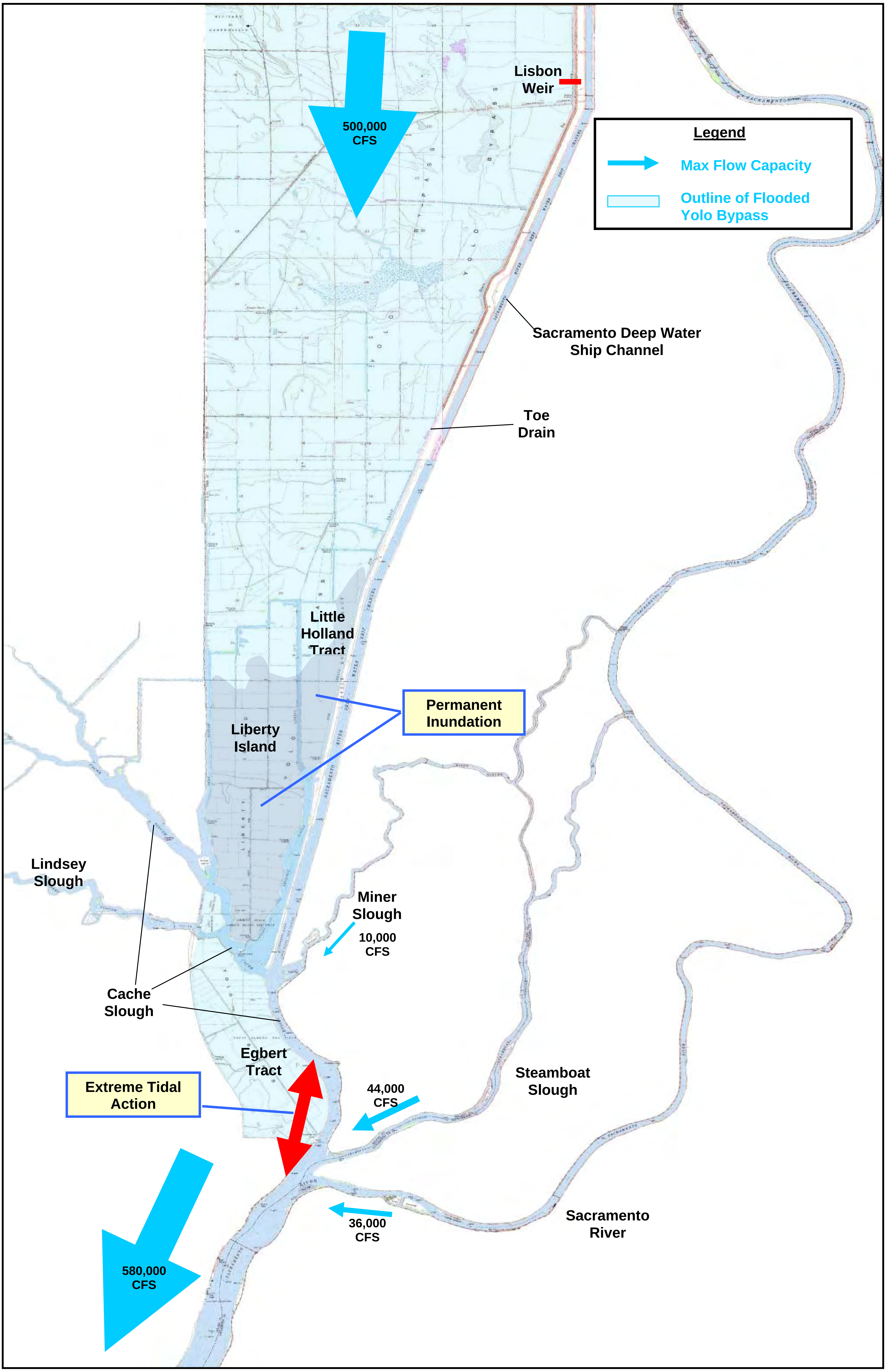
- Water utilization for irrigation ends.
- Water utilization for duck club/habitat begins.

APPENDIX 3. PICTORIAL REPRESENTATION OF MAXIMUM FLOWS IN THE YOLO BYPASS



SUTTER BYPASS AND FEATHER RIVER
SAC RIVER BELOW WILKINS SLOUGH
FLOW (1000 cfs)
DATE
380,000 CFS
HYDROLOGY
Please Note Different Scales on Charts
1997
1998
2002
2001
1990
KLRC Flows Early (Sept-Oct) When it is the Only major Non-Tidal Water Source
SACRAMENTO RIVER
30,000 CFS
Flow Convergence
FREMONT WEIR
FREMONT WEIR
350,000 CFS
KNIGHTS LANDING RIDGE CUT
When Fremont Weir Overtops, it usually Inundates the Entire Bypass Width
Legend
Max Flow Capacity
Outline of Flooded Yolo Bypass
20,000 CFS
30,000 CFS
CACHE CREEK
SACRAMENTO RIVER
City of Woodland Wastewater Treatment (good WQ)
SAC RIVER AT VERONA
107,000 CFS
CACHE CREEK
TULE CANAL
Tule Canal May Lose or Gain from Groundwater
Westside Tributaries Cause Localized Flooding Even When Fremont Weir Does Not Spill
WILLOW SLOUGH (Negligible Flow)
Occasional Reverse Flow of American River into the Sacramento Bypass
SACRAMENTO WEIR
Irrigated Fields Raise Local Groundwater Level
Sacramento Weir is used only during extreme flood events
AMERICAN RIVER
180,000 CFS
City of Davis Wastewater Treatment (Good WQ)
WILLOW SLOUGH BYPASS
SACRAMENTO BYPASS
112,000 CFS
AMERICAN RIVER at FO
6,000 CFS
PUTAH CREEK DIVERSION DAM RELEASES
Limit of Tidal Extent
480,000 CFS
SAC RIVER AT FREEPORT
Minimal Flow in South Fork Putah Creek unless Lake Berryessa Spills. Lake Berryessa glory hole capacity is 45,000 cfs. Power generating plant capacity is 800 cfs. Putah Creek Accord states a minimum of 5 cfs must be in creek at I80.
Check Dam – Impounds Putah Creek water for irrigation and wetlands
TOE DRAIN
SACRAMENTO RIVER
62,000 CFS
Tidal Flow
110,000 CFS
SOUTH FORK PUTAH CREEK
Source: DWR Aquatic Restoration Planning and Implementation – Draft March 23, 2004

Yolo Bypass Conceptual Model – Southern Hydrology



Source: Aquatic Restoration Planning and Implementation – Draft March 23, 2004

APPENDIX 4. MONITORING SITE PHOTOGRAPHS

Appendix 4. Monitoring Site Photographs

Sites are ordered as follows:

- Weirs – Fremont and Sacramento
- Agricultural Drains – Ridge Cut, Willow Slough Bypass, and Z Drain
- West-side Tributaries – Cache Creek, Putah Creek
- In-Bypass – Woodland R1, Woodland R2, Tule Canal, YB Wildlife Area, and Toe Drain

Fremont Weir

Sacramento Weir

Ridge Cut

Willow Slough Bypass

Z Drain

Cache Creek a) low-flow outlet, b) overflow spillway

a)

b)

Putah Creek

Woodland R1

Woodland R2

Tule Canal @ 80

YB Wildlife Area

Toe Drain

APPENDIX 5. QUALITY ASSURANCE PROJECT PLAN

A. PROJECT MANAGEMENT

1. Title Page and Approvals

QUALITY ASSURANCE PROJECT PLAN FOR WATER QUALITY MONITORING FOR THE YOLO BYPASS WATERSHED PLANNING PROJECT, 2003-2004

Contract Manager	Stefan Lorenzato, CalFed Contract Manager, CA Dept. of Water Resources	Date
QA Officer	William Ray, State Water Resources Control Board	Date
City Project Manager	Gary Wegener, City of Woodland	Date
Consultant Project Manager	Armand Ruby, Larry Walker Associates	Date
Contractor QA Officer	Claus Suverkropp, Larry Walker Associates	Date

2. Table of Contents

A. PROJECT MANAGEMENT 1
1. Title Page and Approvals 1
2. Table of Contents 2
3. Distribution List 4
4. Project Organization and Responsibility 5
5. Problem Definition 7
6. Project Description 7
7. Quality Objectives and Criteria for Measurement Data 10
8. Documentation and Records 11

B. DATA ACQUISITION 12
1. Sampling Design 12
2. Sampling Methods Requirements 15
3. Sample Handling and Custody 21
4. Analytical Methods Requirements 22
5. Quality Control Requirements 26
6. Calibration Procedures and Frequency 37
7. Inspection/Acceptance Requirements for Supplies and Consumables 38
8. Quality Control Requirements for Indirect Measurements 38
9. Data Management 38

C. ASSESSMENT AND OVERSIGHT 40
1. Assessments and Response Actions 40
2. Quality Assurance Reports to Management 40

D. DATA VALIDATION AND USABILITY 41
1. Data Review, Validation, and Verification 41
2. Data Reprting… 41

E. REFERENCES 42

APPENDICES

A. Laboratory Contacts
B. Clean Sampling Methods

LIST OF FIGURES

Figure A-1. Monitoring Program Management Structure. 6
Figure B-1. Sampling Sites, Northern Yolo Bypass 13
Figure B-2. Sampling Sites, Southern Yolo Bypass 14

LIST OF TABLES

Table A-1. Primary Distribution List For Quality Assurance Project Plan 4
Table A-2. Parameters Measured For The Yolo Bypass Monitoring Program....................9
Table A-3. Project Implementation Schedule For 2003-2004 Monitoring 10
Table B-1. Yolo Bypass Monitoring Sites 12
Table B-2. Sampling Requirements 18
Table B-3. Summary Of Sampling Sites, Frequency, And Parameters. 19
Table B-4. Sampling Schedule For Analytes By Site And Event 20
Table B-5. Trace Metals: Laboratory Performance Requirements For Analysis Of Water Quality Samples For Trace Metals 23
Table B-6 Pesticides: Analytical Methods And Estimated Reporting Limits 24
Table B-7. General Constituents: Analytical Methods And Project Reporting Limits 25
Table B-8. Pathogen Indicators: Analytical Methods And Estimated Reporting Limits 25
Table B-9a. Project Quality Control Requirements For Analysis Of Water Quality Samples: Frequency And Numbers Of Field Quality Assurance Samples For Mercury, Organic Carbon, General Water Quality Constituents, Pesticides, And Pathogen Indicators. 30
Table B-9b. Project Quality Control Requirements For Analysis Of Water Quality Samples: Trace Metals, Organic Carbon, And General Water Quality Constituents. 31
Table B-9c. Project Quality Control Requirements For Analysis Of Water Quality Samples: Requirements For Chlorinated Pesticide Analyses By Epa Method 608. 32
Table B-9d. Project Quality Control Requirements For Analysis Of Water Quality Samples: Requirements For Organophosphorus Pesticide Analyses By Epa Method 614. 33
Table B-9e. Project Quality Control Requirements For Analysis Of Water Quality Samples: Requirements For Carbamate Pesticide Analyses By Epa Method 632. 34
Table B-9f. Project Quality Control Requirements For Analysis Of Water Quality Samples For Pathogens And Pathogen Indicators. 35
Table B-9g. Project Quality Control Requirements For Analysis Of Water Quality Samples: Requirements For Field Measurements. 35
Table B-10. Project Quality Control Schedule 36

3. Distribution List

Table A-1. Primary Distribution List for Quality Assurance Project Plan

Name	Agency or Company
Stefan Lorenzato	CalFed Contract Manager, CA Dept. of Water Resources
William Ray	QA Officer, State Water Resources Control Board
Casey Walsh Cady	CalFed Liaison, CA Dept. of Food and Agriculture
Gary Wegener	City of Woodland
Armand Ruby	Larry Walker Associates
Claus Suverkropp	Larry Walker Associates
Chris Erichsen	Larry Walker Associates
Todd Albertson	Caltest Analytical Laboratories
Frank Colich	Frontier Geosciences Inc.
Richard Danielson	BioVir Laboratories Inc.
Jeff Miller	Aqua Science, Inc.
Robin Kulakow	Yolo Basin Foundation

4. Project Organization and Responsibility

The Yolo Bypass Water Quality Monitoring Program (Monitoring Program) is being performed by the City of Woodland (the City) as part of a Yolo Bypass Watershed Planning Project. Principal funding for the planning project is provided by a grant from the CalFed Bay-Delta Program. The grant funding is provided subject to the terms of Contract # 4600001691, between Department of Water Resources (DWR) as administrator of the grant program, and the City of Woodland as grantee. The project manager under the grant agreement is Gary Wegener, Director of Public Works, City of Woodland. The project manager for the CalFed Bay-Delta Program is John Lowrie, and the State's contract manager for the agreement is Stefan Lorenzato, Watershed Management Coordinator for DWR. The CalFed project liaison for this project is Casey Walsh Cady, of the California Department of Food and Agriculture.

A stakeholders advisory group informs and influences the decision-making process of this project. These stakeholders include representatives of local municipalities and special districts, state and federal agencies, agriculture, recreational organizations, landowners, environmental organizations, the University of California at Davis, and watershed conservancies. The first of a series of stakeholder meetings was held on July 25, 2003. Sampling sites and pollutants of concern were identified at the second stakeholder meeting, October 15, 2003.

The consultant hired by the City to provide technical and other services for the watershed planning project, including planning and conducting the monitoring program, is Larry Walker Associates (LWA) of Davis, CA. The consultant project manager is Armand Ruby of LWA. The project quality assurance manager is Claus Suverkropp of LWA. Mr. Suverkropp has served in a similar capacity for the Sacramento River Watershed Program (SRWP) and will provide guidance and oversight to assure that the Yolo Bypass Monitoring Program is consistent with the quality assurance/quality control procedures followed by the SRWP.

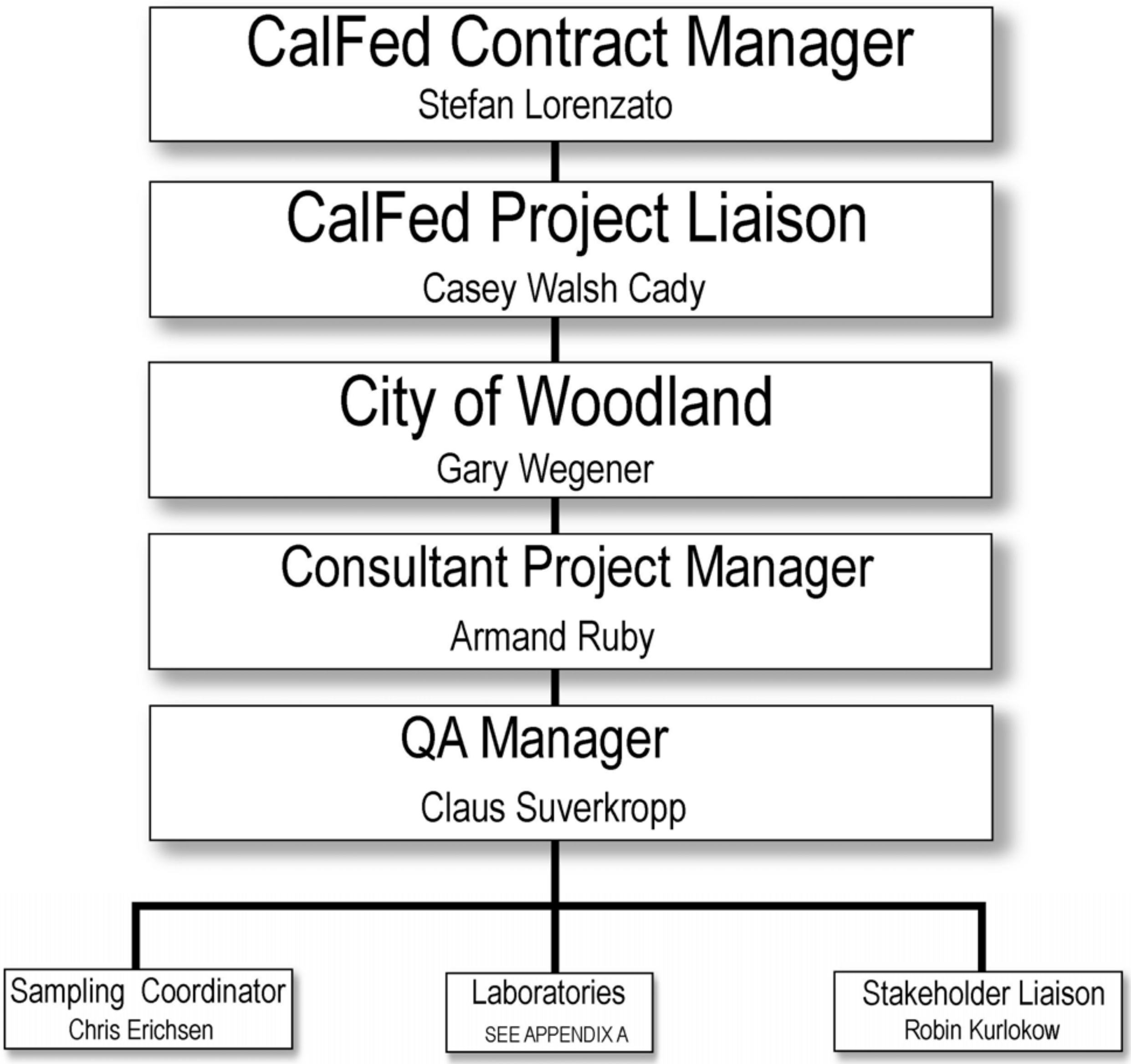
The following subcontractors and municipalities will perform sample analysis:

- Caltest Analytical Laboratories
- Frontier Geosciences Inc.
- BioVir Laboratories, Inc.
- Aqua Science, Inc.
- City of Woodland Wastewater Treatment Plant
- City of Davis Wastewater Treatment Plant

Laboratory analytical responsibilities and primary contacts are listed in Appendix A.

The organizational structure of the Monitoring Program is illustrated in Figure A-1.

Figure A-1. Yolo Bypass Monitoring Program Management Structure



5. Problem Definition

The City of Woodland has received a CalFed grant (CalFed Grant # WSP01-FP-0073; DWR Agreement # 4600001691) to conduct Watershed Management Planning for water quality issues in the Yolo Bypass. The overall goal of the grant project is production of a comprehensive plan for improvement of water quality within the Yolo Bypass. The plan will account for the diverse interests in and uses of the Bypass, and will aim to make the best and most reasonable use of funds available for water quality improvement.

The scope of work covered by the grant includes a water quality monitoring program to characterize Bypass water quality. The monitoring program is scheduled to begin in November 2003 and continue for one year.

6. Project Description

Project Objectives and Approach

Three objectives complete the scope of this watershed planning effort. They are, (1) Define the pollutants of concern affecting the Yolo Bypass and downstream water bodies, (2) Collect data on the Bypass' water quality to identify pollutant sources, their magnitude, and seasonal variation, and (3) Define reasonable and implementable control measures for the pollutants of concern. A stakeholder group was formed to provide input and guidance on implementation of these objectives.

The monitoring program will augment other monitoring efforts that are ongoing in the watershed, including the USGS National Water Quality Assessment Program, Department of Water Resources, City of Woodland, City of Davis, and University of California at Davis. The monitoring program includes chemical, physical, biological and toxicological monitoring elements.

Measurements

The following environmental monitoring elements are included in the monitoring program:

- Mercury and methylmercury in water
- Heavy metals in water
- Organophosphorus, chlorinated, and carbamate pesticides in water
- Pathogen indicator organisms in water
- Organic carbon in water
- General constituents (solids, hardness, nitrate, color, boron) in water
- Toxicity in water

Specific individual parameters measured by the Yolo Bypass monitoring effort are listed in Table A-2. The purposes for monitoring these parameters are discussed below.

Mercury in water. Low levels of mercury and methylmercury in water are of potential concern to human health. Several programs are currently planned or under way in the Yolo Bypass watershed to monitor mercury levels at various locations, including the USGS National Water Quality Assessment. Monitoring of mercury and methylmercury has also been completed in watersheds that drain into the Yolo Bypass, including the Sacramento River Watershed Program, the USGS National Water Quality Assessment, and the CalFed Bay-Delta Program. Proposed Yolo Bypass mercury monitoring will supplement existing data, and planned and ongoing monitoring efforts, with information for six locations. Data obtained will be used to quantify ambient levels of mercury and methylmercury in the Yolo Bypass watershed and to assess whether these levels are causing or contributing to potential human health risks or otherwise adversely affecting beneficial uses. Locations for mercury monitoring were selected to augment and coordinate with existing and planned monitoring efforts in the watershed.

Metals in water. Low levels of metals in water can affect the growth, reproduction and/or survival of sensitive aquatic species. Metals also pose a serious health risk to humans recreating in waters, as well as irrigated crops. Copper is a known serious issue in the Bypass. Many metals have a natural level of occurrence in surface waters, but urban runoff and mine tailings are sources of high metal concentrations such as boron, chromium, copper, iron, lead, and selenium. Yolo Bypass monitoring for metals at six sites will augment or continue fairly extensive monitoring conducted by the USGS NAWQA program, City of Woodland, City of Davis, and the University of California at Davis.

Pesticides in water. Low levels of pesticides in water can affect the growth, reproduction and/or survival of sensitive aquatic species. Pesticides of potential concern to aquatic life in the Yolo Bypass include Organophosphorus (OP), carbamate, and triazine pesticides. The USGS National Water Quality Assessment monitors pesticides in the Yolo Bypass. Yolo Bypass pesticide monitoring will supplement the existing data with information for six locations. Locations for pesticide monitoring were selected on the basis of documented use of these pesticides upstream from the locations monitored and on pesticide-caused toxicity detected in the Bypass.

Pathogen Indicators in water. Pathogens are disease-producing organisms (protozoa, bacteria, viruses) that adversely affect the quality of drinking water and may pose health risks for water contact recreation. Some pathogens are of particular concern, due to their ineffective removal by conventional municipal wastewater treatment technologies. The Tule Canal, the perennial drain on the eastern side of the Bypass, is seasonally used for fishing and small boat recreation, and is also a source of irrigation water for unprocessed crops. The Tule Canal becomes the Toe Drain as it flows southward past Interstate Route 80, and then drains into the Sacramento-San Joaquin Bay-Delta, a drinking water source for bay-delta communities including San Francisco. Because sampling and analysis for specific pathogen organisms is difficult and problematic, indicator organisms are often used as surrogates. Pathogen indicator monitoring will be employed to assess the presence of indicator organisms (total and fecal coliforms and *Escherichia coli*) at monitoring locations throughout the Bypass.

Organic carbon in water. The organic content of water (measured as organic carbon) is a parameter important to drinking water suppliers. High levels of organic compounds in source waters can lead to the production of disinfection by-products as a result of conventional water treatment. These by-products pose human health problems at relatively low concentrations. For these reasons, baseline data on typical organic carbon levels and seasonal variability of those levels in the Yolo Bypass are important to the assessment of drinking water uses. Yolo Bypass monitoring for organic carbon (dissolved and total) at six sites will augment or continue fairly extensive monitoring conducted by the USGS NAWQA program, City of Woodland, City of Davis, and the University of California at Davis.

General constituents (suspended and dissolved solids, total and dissolved organic carbon, hardness, color, nitrate and boron) in water. These conventional water quality parameters are important to the evaluation of the attainment of a variety of uses, including drinking water supply, recreation, irrigation, aquatic habitat, and agricultural supply. Data on these parameters is available from a number of other programs, including USGS NAWQA, SRWP, City of Woodland, City of Davis, and the University of California at Davis. Yolo Bypass monitoring will augment these ongoing data collection efforts for these constituents at six sites.

Toxicity in water. Ambient samples of water can be tested in the laboratory for toxicity to provide an indication of the conditions that exist in the natural environment. Standard test species and test procedures are used to provide reliable and comparable results. Toxicity is considered to occur when test species are adversely affected by exposure to ambient water. Adverse effects may include impaired growth or reproduction, abnormalities, or mortality of test species. Effects may occur rapidly (acute toxicity) or may occur over a longer period (chronic toxicity). Toxicity testing in water will be performed at four locations in the watershed to assess chronic toxicity testing using both the fathead minnow (P*imephales promelas*) and the water flea (*Ceriodaphnia dubia*). Sites for aquatic toxicity monitoring were selected to provide an overall survey of the distribution of toxicity in the watershed, to coordinate with existing monitoring programs, and to characterize causes of observed toxicity.

Table A-2. Parameters Measured for the Yolo Bypass Monitoring Program

Analyte
Organophosphate Pesticides by EPA 614/8141
Chlorinated Pesticides by EPA 608/8081
Carbamates by EPA 632/8032
Mercury (total)
Methyl Mercury
Metals (Al, B, Cr, Cu, Pb, Se) - dissolved and total
Hardness
Nitrate
TOC
Color
DOC
TSS
TDS
Total & Fecal Coliform, plus E. coli
Chronic Toxicity

Assessment Tools

The QAPP and any amendments to QAPP elements will be reviewed and approved by project Quality Assurance Officers, and by the Quality Assurance Manager prior to the initiation of monitoring.

Project Schedule

The proposed schedule for Yolo Bypass monitoring is summarized in Table A-3.

Table A-3. Project Implementation Schedule for 2003-2004 Monitoring

Finalize and Execute Contracts for 2003-2004 Monitoring	11/1/03
Submit Revised QAPP to CalFed for Review	11/12/03
Receive Comments on Amended QAPP	12/8/03
Respond to CalFed Comments on Revised QAPP	12/22/03
Conditional Approval for QAPP for 2003-2004 Monitoring	11/21/03
Initiate 2003-2004 Monitoring	11/22/03
Final Approval for QAPP	12/31/03

Sampling Schedule

The sample collection frequency varies by site, flooding season, and parameter to be tested. The proposed monitoring includes six sites and six events (bimonthly) for most constituents, and 10 sites and 12 events for mercury, bacteria, and the field parameters. (Note that although there are 12 sites, under typical conditions the Fremont Weir and Sacramento Weir will not be spilling, so of the 12 sites only 10 will nominally be collectable.)

7. Quality Objectives and Criteria for Measurement Data

The objective of data collection for this program is to produce data that represent, as closely as possible, *in situ* conditions of the Yolo Bypass watershed. This objective will be achieved by using the methods specified in this QAPP to collect and analyze water samples. Assessing the program's ability to meet this objective will be accomplished by evaluating the resulting laboratory measurements in terms of detection limits, precision, accuracy, comparability, representativeness, and completeness, as presented in Section B of this document.

8. Documentation and Records

Data to be included in data reports

For each sample event, the field crew shall provide the Quality Assurance Manager with copies of relevant pages of the field logs and copies of the Chain of Custody forms for all samples submitted for analysis. At a minimum, the following sample-specific information will be provided for each sample collected:

- sample ID (unique for each sample and replicate)
- monitoring location
- sample depth
- sample type, e.g. grab or composite type (cross-sectional, flow-proportional, etc.)
- number of sub-samples in composite (if appropriate)
- QC sample type (if appropriate)
- date and time(s) of collection
- requested analyses (specific parameters or method references)

For each sample analyzed, the analyzing laboratory shall provide the Quality Assurance Manager with the following information:

- sample ID
- date of sample receipt
- dates of analysis
- analytical method(s)
- method detection limit (if appropriate)
- reporting limit (if appropriate)
- measured value of the analyte or parameter.

In addition, the analyzing laboratory shall provide results from all laboratory QC procedures (blanks, duplicates, spikes, reference materials, etc.) and the sample IDs associated with each analytical sample batch.

Reporting Format

In addition to the laboratory's standard reporting format, all results meeting data quality objectives, and results having satisfactory explanations for deviations from objectives, shall be reported in tabular format on electronic media.

B. DATA ACQUISITION

1. Sampling Design

The monitoring program includes monitoring at 10 locations in the Yolo Bypass. Four sites are located on the perennial channel, the Tule Canal (e.g., Toe Drain). Eight sites are located on major inputs to the Bypass, including two sites at flood weirs. These sites cover over 45 miles of the Yolo Bypass system and represent a drainage area of over 59,000 acres. The Yolo Bypass monitoring sites are listed in Table B-1 and illustrated in Figures B-1 and B-2.

Water quality monitoring samples will be collected as "event-based" grab samples. Table A-3 in the previous section provides a summary of sampling frequency and parameters monitored at each site.

Table B-1. Yolo Bypass Monitoring Sites

Site description	Site ID	Site Type
Sacramento River Overflow/Fremont Weir	1	Input – Sac R overflow
Knight's Landing Ridge Cut	2	Input channel
Cache Creek	3	Input creek
Willow Slough Bypass	4	Input channel
Yolo Bypass Wildlife Area – lift pump	5	Input – pumped
Putah Creek	6	Input creek
Z Drain – Dixon RCD	7	Input channel
Sacramento River Overflow/Sacramento Weir	8	Input – Sac R overflow
Tule Canal – Woodland R1	9	East side drain channel
Tule Canal – Woodland R2	10	East side drain channel
Tule Canal at north-east corner of I-80	11	East side drain channel
Toe Drain at north-east corner of Little Holland	12	East side drain channel

Figure B-1. Sampling Sites, Northern Yolo Bypass

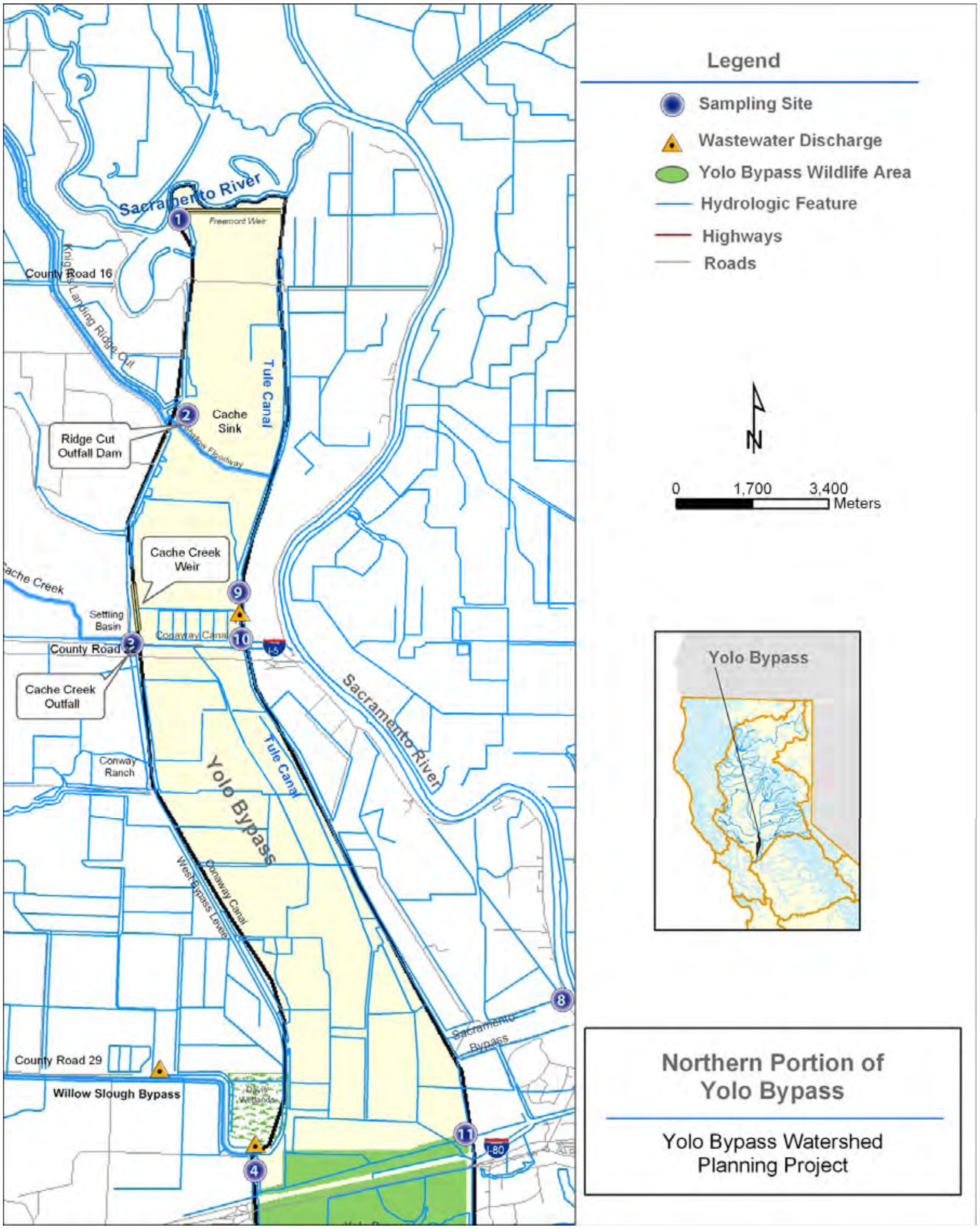
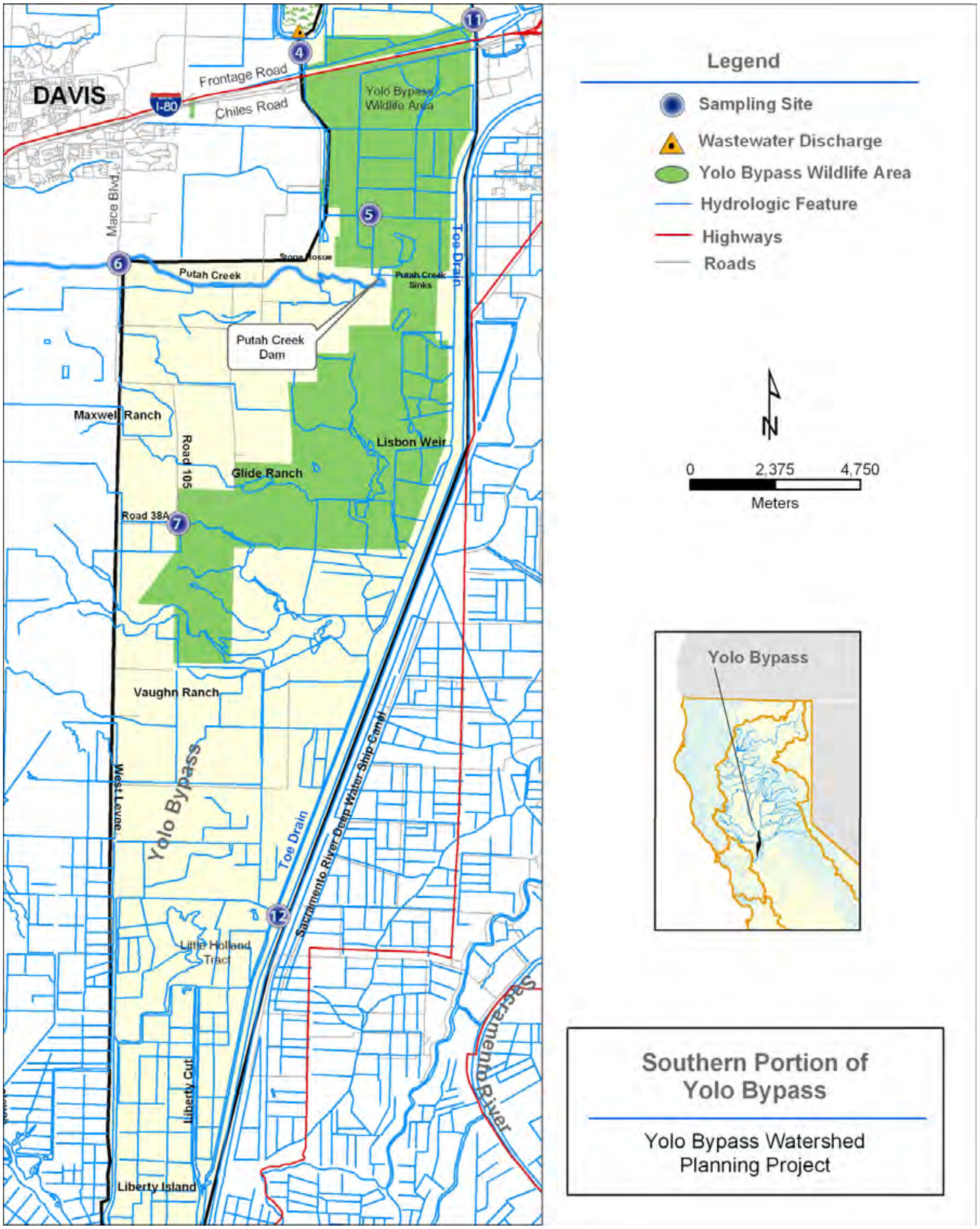


Figure B-2.   Sampling Sites, Southern Yolo Bypass



2. Sampling Methods Requirements

Samples will be collected from surface waters only. Three different sample collection methods will be used for the monitoring elements in water: (1) basic water quality sampling, (2) pathogen indicator sampling, and (3) toxicity sampling. For each of these methods described or referenced, it is the combined responsibility of field crew manager to determine if the performance requirements of the specific sampling method have been met, and to collect an additional sample if required. Sampling personnel will carry copies of the QAPP and any relevant SOPs with them in the field for reference during sampling. Descriptions of specific sampling methods and requirements are provided below.

2.1 Basic Water Quality Characteristics

Basic water quality monitoring will include sampling for mercury and methylmercury, pesticides, metals (Al, B, Cu, Be, Cr, Pb, Se), hardness, total suspended solids, total dissolved solids, nitrate, total organic carbon, dissolved organic carbon, and color. Field-measured parameters (temperature, dissolved oxygen, specific conductivity, and pH) will also be measured at each site and event. Field parameters will be measured using a YSI Model 57 Oxygen Meter for dissolved oxygen, VWR Scientific Traceable Digital Thermometer (Cat. #61220416) for temperature, Orion Model 230A pH meter, and an Orion Model 130 conductivity meter, or comparable instrument(s).

All water quality samples will be collected using clean techniques that minimize sample contamination. Sampling methods will generally conform to EPA "clean" sampling methodology described in *Method 1669: Sampling Ambient Water for Trace Metals* (USEPA 1995a). Specific methods are also documented in Appendix B. Samples will generally be mid-depth grab samples and will be collected from shore using an extendable grab pole or using a peristaltic pump and acid-cleaned polyethylene or Teflon™ tubing. Grab samples will be collected directly into the required sample containers.

After collection, samples will be stored at 4˚C until arrival at the contract laboratory. Samples to be analyzed for mercury will be preserved using ultrapure hydrochloric or bromochloric acid at the contract laboratory, immediately on arrival. Samples to be analyzed for other constituents will be preserved in the field, as appropriate (Table B-2).

This sample collection method requires that the sample collection tubing, and the sample bottle and lid come into contact only with surfaces known to be clean, or with the water sample. Additionally, mercury samples must have no air bubbles or head space present in the bottle immediately following sample collection. If air is present in the sample container for mercury analyses, additional sample will be aliquotted into the same sample bottle. If the performance requirements for specific samples are not met, the sample will be re-collected. If contamination of the sample container is suspected, a fresh sample container will be used.

2.2 Pathogen Indicators

Pathogen monitoring will include sampling for pathogen indicator organisms (fecal and total coliform bacteria, and *E. coli*). Samplers must wear gloves when collecting any pathogen indicator samples.

Bacteria

Samples analyzed for bacteria will be collected as near-surface grab samples from mid-stream. Sampling for bacteria will be performed according to the sampling procedures detailed for Standard Methods 9221B and 9221E (APHA *et al*. 1995). In brief, the sampling procedures are summarized as follows:

- Sample containers should be cleaned and sterilized using procedures described in Standard Methods 9030 and 9040.
- Wherein waters suspected to contain a chlorine residual, sample bottles should contain a small amount of sodium thiosulfate ($Na_2S_2O_3$) sufficient to neutralize bactericidal activity. For water containing high concentrations of copper or zinc, sample bottles should contain sufficient EDTA solution to reduce metal toxicity. Note that these conditions are rare in surface waters.
- Sample bottles may be glass or plastic (e.g. polypropylene) with a capacity of at least 120 mL. Once sterilized, sample bottles are to be kept closed until they are to be filled.
- When removing caps from sample bottles, be careful to avoid contaminating inner surface of caps or bottles.
- Using aseptic techniques fill sample bottles leaving sufficient air space to facilitate mixing by shaking. Do not rinse bottles.
- Recap bottles tightly.

If at any time the sampling crew suspects that the sample or sampling container has been contaminated, the sample should be re-collected into a new sample container.

After collection, store samples at 4˚C until arrival at the contract laboratory. Bacteriological tests must be set up within 6 hours from collection. The 20th edition of Standard Methods (APHA et al. 1995) recommends analysis of samples as soon as possible, but specifies that potable water samples analyzed for compliance purposes may be held for up to 6 hours (below 10˚C) until time of analysis.

2.3 Aquatic Toxicity

Collection of water samples for analysis of ambient water column toxicity will be performed in accordance with guidance for sampling and sample handling documented in *Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms* (USEPA 1994a). In brief, the sampling requirements for toxicity testing are as follows:

- Water collected for toxicity tests will consist of grab samples.
- Samples will be collected directly into 4-L amber glass bottles, using the same equipment and procedures as for basic water quality samples (previously described in section 2.1).
- Samples will be filtered in the laboratory as required for specific toxicity tests.
- After collection, samples will be chilled and maintained at 4˚C until testing.
- Toxicity tests will be initiated within 48 hours of sampling.

In some cases where significant toxicity is observed during aquatic toxicity testing, samples may be analyzed for any of the chemical parameters included in this QAPP. The specific analyses to be performed will depend on the pattern of toxicity observed, including any decision to filter samples for chemical analysis. Every effort will be made to be consistent with the sample requirements documented herein for the specific analyte. Because requirements for sample and preservation holding times, filtration, and original sample containers may not be strictly met, the results of the analyses will be used primarily for determining or confirming causes of toxicity, and will be qualified for any other use. Laboratories selected to perform these analyses must meet the same QA performance criteria used to select other laboratories for this monitoring program.

A summary of the numbers of sampling sites and events for the parameters to be analyzed is provided in Table B-3. A schedule of the sampling frequency for analytes by site and event are provided in Table B-4. The list of sampling sites in Table A-3 supersedes all lists of sampling sites included in previous versions of QAPPs or monitoring plans, approved or unapproved, relating to the monitoring described herein.

Table B-2. Sampling Requirements

Parameter	Sample Container	Sample Volume[1]	Immediate Processing and Storage	Holding Time[2]
Mercury				
Total Mercury	Teflon™, or glass w/ PTFE-lined cap	250 mL	Store at 4°C; Preserve with HCl within 48 hours	28 days
Methylmercury[3]	Teflon™, or glass w/ PTFE-lined cap	250 mL	Store at 4°C; Preserve with HCl within 48 hours	6 months
Pesticides				
Organophosphates	Amber Glass	1 Liter	Store at 4°C; Extract within 7 days	7 days
Carbamates	Amber Glass	1 Liter	Store at 4°C; Extract within 7 days	7 days
Chlorinated	Amber Glass	1 Liter	Store at 4°C; Extract within 7 days	7 days
General Constituents				
Hardness	Polyethylene	250 mL	Preserve to =pH 2 with HNO3; Store at 4°C	6 months
Total Suspended Solids	Polyethylene	200 mL	Store at 4°C;	7 days
Total Dissolved Solids	Polyethylene	100 mL	Filtered; Store at 4°C	7 days
Total Organic Carbon	Amber Glass, PTFE-lined cap	40 mL	Preserve w/ H_2SO_4; Store at 4°C;	7 days
Dissolved Organic Carbon	Amber Glass, PTFE-lined cap	40 mL	Field-filtered[3]; Preserve w/ H_2SO_4; Store at 4°C;	7 days
Color	Polyethylene	100 mL	Store at 4°C;	48 hours
Nitrogen and Phosphorus Compounds				
Nitrate	Polyethylene	500 mL	Store at 4°C	48 hours
Pathogens				
Total & fecal coliforms, *E. coli*	Polyethylene	100 mL	Store at 4°C	6 hours[4]
Toxicity				
Aquatic bioassays and chemistry[6]	Amber Glass	10 L	Store at 4°C	36 hours[5]
Metals				
Trace metals (total & dissolved) (Al, B, Cu, Be, Cr, Pb, Se),	Polyethylene	500 mL	Filter for dissolved fraction prior to preservation Preserve to =pH 2 with HNO3; store at 4°C	6 months

1. Additional volumes may be required for QC analyses; NA = Not Applicable
2. Holding time after initial preservation or extraction.
3. Field-filtration and preservation are preferred, but DOC samples may be filtered and preserved in the laboratory within 48 hours, if field filtration is not practical.
4. Samples for bacteria analyses should be set up as soon as possible.
5. Results for tests initiated after 36 hours will be qualified, as appropriate.
6. For interpretation of toxicity results, samples may be split from aquatic toxicity samples in the laboratory and analyzed for specific chemical parameters. All other sampling requirements (sample containers, filtration, preservation, holding times) for these samples are as specified in this document for the specific analytical method. Results of these analyses are qualified for any other use (e.g. characterization of ambient conditions) because of potential holding time exceedances and variance from sampling requirements.

Table B-3. Summary of Sampling Sites, Frequency, and Parameters.

Analyte	Laboratory	Sites	Events
Organophosphate Pesticides by EPA 614/8141	CalTest	6	6
Chlorinated Pesticides by EPA 608/8081	CalTest	6	6
Carbamates by EPA 632/8032	CalTest	6	6
Mercury (total)	Frontier	10	12
Methyl Mercury	Frontier	6	6
Metals (Al, B, Be, Cu, Cr, Pb, Se)	CalTest	6	6
Nitrate	CalTest	6	6
Hardness	CalTest	6	6
Color	CalTest	6	6
TDS	CalTest	6	6
TOC	CalTest	6	6
DOC	CalTest	6	6
TSS	CalTest	6	6
Total & Fecal Coliform, and *E. coli*	BioVir	10	12
3-Species Chronic Toxicity	TBD	4	4
Field Measurements			
Electrical Conductivity		10	12
Turbidity		10	12
Dissolved Oxygen		10	12
pH		10	12
Temperature (F)		10	12

Table B-4. Sampling Schedule for Analytes by Site and Event

SITE		EVENTS											
		Nov	Dec	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct
Class	#	1	2	3	4	5	6	7	8	9	10	11	12
Inputs	1			1, 2, 4	1, 2, 4	1, 2, 4							
	2	1, 2, 3, 4	1	1, 2, 3, 4, 5	1	1	1, 2, 3, 4, 5	1	1, 2 ,3, 4	1,	1, 2, 3, 4, 5	1, 2. 3, 4, 5	1
	3	1, 2, 3, 4	1	1, 2, 3, 4, 5	1	1	1, 2, 3, 4, 5	1	1, 2 ,3, 4	1	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1
	4	1, 2, 3, 4	1	1, 2, 3, 4, 5	1	1	1, 2, 3, 4, 5	1	1, 2 ,3, 4	1	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1
	5	1	1	1	1	1	1	1	1	1	1	1	1
	6	1, 2, 3, 4	1	1, 2, 3, 4	1	1	1, 2, 3, 4	1	1, 2 ,3, 4	1	1, 2, 3, 4	1, 2, 3, 4	1
	7	1	1	1	1	1	1	1	1	1	1	1	1
	8			1, 2, 4	1, 2, 4	1, 2, 4							
East Channel	9	1	1	1	1	1	1	1	1	1	1	1	1
	10	1	1	1	1	1	1	1	1	1	1	1	1
	11	1, 2, 3, 4	1	1, 2, 3, 4, 5	1	1	1, 2, 3, 4, 5	1	1, 2 ,3, 4	1	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1
	12	1, 2, 3, 4	1	1, 2, 3, 4	1	1	1, 2, 3, 4	1	1, 2 ,3, 4	1	1, 2, 3, 4	1, 2, 3, 4	1

1 = Total Mercury and Total and fecal coliforms, including E. Coli (10/12)

2 = Methylmercury and Trace Metals (6/6)

3 = Pesticide group: Chlorinated, organophosphorus, and carbamates (6/6)

4 = General constituents: Hardness, TOC, DOC, TSS, TDS, Color, and Nitrate (6/6)

5 = Aquatic bioassay and chemistry (4/4)

Grey *indicates site sampled only when weir is breached*

3. Sample Handling and Custody

All samples will be packed in wet ice or frozen ice packs during shipment, so that they will be kept at approximately 4˚C. Samples will be shipped in insulated containers. All caps and lids will be checked for tightness prior to shipping. All samples will be handled, prepared, transported and stored in a manner so as to minimize bulk loss, analyte loss, contamination or biological degradation. Sample containers will be clearly labeled with an indelible marker. Where appropriate, samples may be frozen to prevent biological degradation. Water samples will be kept in Teflon™, glass, or polyethylene bottles and kept cool at a temperature of 4˚C until analyzed. Maximum holding times for specific analyses are listed in Table B-2.

All samples remaining after successful completion of analyses will be disposed of properly. It is the responsibility of the personnel of each analytical laboratory to ensure that all applicable regulations are followed in the disposal of samples or related chemicals.

Chain-of-custody procedures require that possession of samples be traceable from the time the samples are collected until completion and submittal of analytical results. A complete chain-of-custody form is to accompany the transfer of samples to the analyzing laboratory. A sample is considered under custody if:

- it is in actual possession;
- it is in view after in physical possession;
- it is placed in a secure area (accessible by or under the scrutiny of authorized personnel only after in possession)

With the exception of aquatic toxicity samples, samples will be kept for a minimum of 28 days after collection. The QA officer for each laboratory will evaluate the data before the end of the 28 day period. After this period, samples may be disposed of properly when all analyses have been completed, and data quality objectives have been met. Aquatic toxicity samples may be disposed of after initial testing is complete and no further analyses are warranted.

3.1 Sample Holding Times

Data quality objectives for sample holding times conform to recommendations documented in the analytical methods for individual parameters. The contract laboratory will analyze all samples before the maximum allowable holding time for any sample is exceeded. Holding times for specific parameters are presented in Table B-2.

3.2 Field Log

Field crews shall be required to keep a field log for each sampling event. The following items should be recorded in the field log for each sampling event:

- site name and/or number;
- time of sample collection;
- sample ID numbers, including etched bottle ID numbers for Teflon™ mercury sample containers and unique IDs for any replicate or blank samples;
- results of any field measurements (temperature, D.O., pH, conductivity, turbidity) and the time that measurements were made;

- qualitative descriptions of relevant water conditions (e.g. color, flow level, clarity) or weather (e.g. wind, rain) at the time of sample collection;
- description of any unusual occurrences associated with the sampling event, particularly those that may affect sample or data quality.

Appropriate pages from the sampling log will be photo-copied and transmitted to the Quality Assurance Manager at the conclusion of each sampling run.

The field crews shall have custody of samples during field sampling. Chain of custody forms will accompany all samples during shipment to contract laboratories. All water quality samples will be transported to the analytical laboratory by the field crew or by overnight courier.

3.3 Laboratory Custody Log

Laboratories shall maintain custody logs sufficient to track each sample submitted and to analyze or preserve each sample within specified holding times.

4. Analytical Methods Requirements

4.1 Basic Water Chemistry Analyses

Water quality samples may be analyzed for filtered and unfiltered fractions of mercury and methylmercury, trace elements, pesticides, and conventional water quality constituents. Analytical methods are summarized in Tables B-5 through B-8.

Field Measurements

Prior to analysis of any environmental samples, the field equipment must have demonstrated the following instrument measurement resolutions:

Parameter	Resolution
Dissolved Oxygen	0.1 standard unit
Flow (cfs)	0.1 cfs
pH	0.1 standard unit
Speicifc Conductivity	10 microSiemens/cm
Temperature	0.5 ˚C

Mercury and Trace Metals

Prior to analysis of any environmental samples for mercury, methylmercury, or other trace metals, the laboratory must have demonstrated the ability to meet the minimum performance requirements for each analytical method. Initial demonstration of laboratory capability includes the following:

- the ability to produce a detection limit equal to or less than the method detection limit (MDL) listed in Table B-5;
- the ability to generate acceptable precision and recovery, as defined by *s* and *X* in Table B-5;
- the ability to generate average recoveries within 15% of the stated concentration in a Standard Reference Material (SRM).

Procedures for analytical performance requirements, extraction procedures, and waste disposal and pollution prevention requirements are detailed in the laboratory's Standard Operating Protocols or EPA Method documents for each analytical method. EPA's recommended minimum performance requirements are summarized for each trace element in Table B-5.

Pesticides

Prior to analysis of any environmental samples for pesticides, the laboratory must have demonstrated the ability to meet the minimum performance requirements for each analytical method. Initial demonstration of laboratory capability includes the following:

- the ability to produce a reporting limit equal to or less than the reporting limit (RL) listed in Table B-6;
- the ability to generate acceptable precision and recovery, as defined by the specified method;

Procedures for demonstrating analytical performance requirements, extraction procedures, and waste disposal and pollution prevention requirements are detailed in the EPA Method documents for each analytical method. EPA's recommended minimum performance requirements are summarized in the method documents.

Conventional Constituents

Analyzing laboratories must demonstrate the ability to produce reporting limits approximately equal to or below the estimated reporting limits listed in Table B-7. Precision and replicate measurements in ambient waters should be less than 20% Relative Percent Difference for all constituents. Average recovery of appropriate reference materials should be between 80 and 120% for all constituents.

Table B-5. Trace Metals: Laboratory Performance Requirements for Analysis of Water Quality Samples for Trace Metals

Analyte	**Method (1)**	**MDL(2), µg/L**	**RL(3), µg/L**	**Accuracy(4), *X***	**Precision(5), *s***	**MS Rec(6)**	**MS/MSD RPD(7)**
Aluminum	EPA 200.8	.06	0.1	80-120	20	80-120	20
Beryllium	EPA 200.8	.7	10	80-120	20	80-120	20
Boron	EPA 200.8	0.1	0.5	80-120	20	80-120	20
Chromium	EPA 200.8	0.2	0.5	80-120	20	80-120	20
Copper	EPA 200.8	0.3	0.5	80-120	20	80-120	20
Lead	EPA 200.8	0.04	0.25	80-120	20	80-120	20
Mercury	EPA 1631(8)	0.15	0.15	75-125	25	75-125	25
Methyl-mercury	EPA 1630(8)	0.025	0.025	75-125	25	75-125	25
Selenium	EPA 200.8	0.02	0.1	80-120	20	80-120	20

(1) SOP or EPA Method number
(2) Method Detection Limit
(3) Target Project Reporting Limit
(4) X = Average recovery for demonstration of initial performance
(5) s = standard deviation of recovery for demonstration of initial performance
(6) Percent recovery of matrix spike
(7) Relative percent difference of matrix spike duplicates
(8) Mercury and methyl-mercury analytical methods may be modified by laboratory in accordance with USEPA performance-based analytical performance criteria

Table B-6 Pesticides: Analytical Methods and Estimated Reporting Limits

Analyte	RL[1]	Analyte	RL[1]
Organophosphorus pesticides by EPA Method 614/8141			
Azinphosmethyl	1.0	Fenthion	0.10
Bolstar	0.10	Malathion	0.10
Chlorpyrifos	0.05	Merphos	0.10
Coumaphos	0.20	Mevinphos	0.70
Def	0.10	Naled	0.50
Demeton-S	0.20	Parathion, ethyl	0.10
Diazinon	0.05	Parathion, methyl	0.10
Dichlorovos	0.20	Phorate	0.10
Dimethoate	0.10	Prowl	0.10
Disulfoton	0.10	Ronnel	0.10
EPN	0.10	Stirophos	0.10
EPTC	0.10	Tokuthion	0.10
Ethion	0.10	Trichloronate	0.10
Ethoprop	0.10	Trifluralin	0.10
Fensulfotion	0.50		
Carbamate pesticides by EPA Method 632/8032			
Aldicarb	0.8	Linuron	0.8
Aminocarb	0.8	Methiocarb	0.8
Barban	7.0	Methomyl	7.0
Benomyl (Carbendazim)	0.8	Mexacarbate	0.8
Bromacil	0.8	Monuron	0.8
Carbaryl	0.14	Neburon	0.8
Carbofuran	0.14	Oxamyl	7.0
Chloropropham	7.0	Propachlor	7.0
Chloroxuron	0.8	Propoxur	0.8
Diuron	0.8	Siduron	0.8
Fenuron	0.8	Tebuthiuron	0.8
Fluometuron	0.8		
Chlorinated pesticides by EPA Method 608/8081			
Aldrin	0.005	Lindane	0.01
BHC-beta isomer	0.01	o,p'-DDD	0.01
Cis-Chlordane	0.01	o,p'-DDE	0.01
Dieldrin	0.01	o,p'-DDT	0.01
Endrin	0.01	p,p'-DDD	0.01
Heptachlor epoxide	0.01	p,p'-DDE	0.01
Heptachlor	0.01	p,p'-DDT	0.01
Hexachlorobenzene (HCB)	0.01		

(1) Reporting Limit for project, based on detection limits achievable by analyzing laboratory. Because detection limits are affected by differences in sample matrices, the RLs listed are estimates.

Table B-7. General Constituents: Analytical Methods and Project Reporting Limits

Constituent	Fractions	Method # (1)	RL, mg/L (2)
Suspended solids	Total	EPA 160.2	5
Hardness	Total, as CaCO3	EPA 130.2	5
Turbidity	Total	EPA 180.1	1.0 NTU
Dissolved solids	Dissolved	EPA 160.1	5
Nitrate	Total	EPA 300	0.05
Organic Carbon	Total, Dissolved	SM 5310 C	0.2
Color	Filtered	EPA 110.1	NA

(1) Standard Methods (SM), EPA Method number, or reference.
(2) Reporting Limit for project, based on detection limits achievable by analyzing laboratory

4.2 Pathogen Analyses

Water quality samples will be analyzed for fecal and total coliform bacteria, and *E. coli*. Analysis for coliform bacteria must be performed in accordance with the methods referenced in Table B-8. The laboratory must demonstrate the ability to meet the performance requirements described in this method.

Table B-8. Pathogen Indicators: Analytical Methods and Estimated Reporting Limits

Constituent	Method (1)	RL (2)
Total Coliform	SM 9221B	2 MPN/100 mL
Fecal Coliform	SM 9221E	2 MPN/100 mL
E. coli	SM 9221B/E mod. MUG	2 MPN/100 mL

(1) Standard Methods (SM) number or method reference.
(2) Reporting Limit for project.

4.3 Aquatic Toxicity Analyses

Water quality samples will be analyzed for short-term chronic toxicity using both the fathead minnow (P*imephales promelas*) and the water flea (*Ceriodaphnia dubia*). All samples are to be initially tested at the 100% solution concentration. Determination of chronic toxicity shall be performed generally as described in *Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms* (USEPA 1994).

5. Quality Control Requirements

The types of quality control assessments used in the Yolo Bypass Monitoring Program are discussed below. Quality control requirements and schedules are summarized in Tables B-9a through B-9g. Detailed procedures for preparation and analysis of quality control samples are provided in the analytical method documents. A project quality control schedule for the Yolo Bypass project is provided in Table B-10.

5.1 Qualitative Objectives

Comparability

Comparability of the data can be defined as the similarity of data generated by different monitoring programs. For the purpose of the Yolo Bypass Monitoring Program, this objective is addressed primarily by using standard sampling and analytical procedures where possible. Additionally, comparability of analytical data is addressed by analysis of standard reference materials (discussed subsequently in this document).

Representativeness

Representativeness can be defined as the degree to which the environmental data generated by the monitoring program accurately and precisely represent actual environmental conditions. For the Yolo Bypass, this objective is addressed by the overall design of the monitoring program. Specifically, assuring the representativeness of the data is addressed primarily by selecting appropriate locations, methods, times, and frequencies of sampling for each environmental parameter, and by maintaining the integrity of the sample after collection. Each of these elements of the quality assurance program are addressed elsewhere in this document.

Completeness

Data completeness is a measure of the amount of successfully collected and validated data relative to the amount of data planned to be collected for the project. Completeness is usually expressed as a percentage value. A project objective for percent completeness is typically based on the percentage of the data needed for the program or study to reach valid conclusions. Because this is a one year long monitoring program with monthly sample collection, data that are not successfully collected for a specific sample event or site can not be recollected at a later sampling event. For this reason, most of the data planned for collection are considered absolutely critical. Therefore, program personnel will strive for a 100% completion rate for the 12 months of collection. The program goals for data completeness are based on the planned sampling frequency and a subjective determination of the relative importance of the monitoring element within the Monitoring Program. As shown in Tables B-9b – B-9f, the acceptable completeness is set at 90% for laboratory sample analysis, to account for circumstances beyond the control of field personnel, such as Bypass flooding or loss of samples in shipping. The acceptable completeness for field measurements is set at 95%, as shown in Table B-9g.

5.2 Field Procedures

For basic water quality analyses, quality control samples to be prepared in the field will consist of field blanks and field duplicates. The number of field duplicates and field blanks are set to achieve an overall rate of at least 10% of all analyses for a particular parameter. The external QA samples are rotated among sites and events to achieve the overall rate of 10% field duplicate samples and 10% field blanks (as appropriate for specific analyses).

<u>Field Blanks</u>

The purpose of analyzing field blanks is to demonstrate that sampling procedures do not result in contamination of the environmental samples. Field blanks will be prepared and analyzed for all analytes of interest at the rate of one per sample event, along with the associated environmental samples. Field blanks will consist of laboratory-prepared blank water processed through the sampling equipment using the same procedures used for environmental samples. If any analytes of interest are detected at levels greater than the Reporting Limit (RL) for the parameter, the sampling crew should be notified so that the source of contamination can be identified (if possible) and corrective measures taken prior to the next sampling event. If the concentration in the associated samples is less than five times the value in the field blank, the results for the environmental samples may be unacceptably affected by contamination and should be qualified as an *upper limit* (UL) at the reported value.

<u>Field Duplicates</u>

The purpose of analyzing field duplicates is to demonstrate the precision of sampling and analytical processes. Field duplicates will be prepared at the rate of one per sampling event, and analyzed along with the associated environmental samples. Field duplicates will consist of two aliquots from the same composite sample, or of two grab samples collected in rapid succession. If the relative Percent Difference (RPD) of field duplicate results is greater than 25% and the absolute difference is greater than the RL, both samples should be reanalyzed. If an RPD greater than 25% is confirmed by reanalysis, environmental results will be qualified as *estimated*. The sampling crew should be notified so that the source of sampling variability can be identified (if possible) and corrective measures taken prior to the next sampling event.

5.3 Laboratory Analyses

For basic water quality analyses, quality control samples prepared in the contract laboratory(s) will typically consist of equipment blanks, method blanks, standard reference materials, laboratory duplicates, matrix spikes, and matrix spike duplicates. Laboratory analyses for bacteria will include negative and positive quality control samples, as specified in the method documents.

<u>Equipment Blanks</u>

The purpose of analyzing equipment blanks is to demonstrate that sampling equipment is free from contamination. Prior to using sampling equipment for the collection of environmental samples, the laboratory responsible for cleaning and preparation of the equipment will prepare bottle blanks and sampler blanks. These will be prepared and analyzed at the rate of one each per batch of bottles or sampling equipment. The blanks will be analyzed using the same analytical methods specified for environmental samples. If any analytes of interest are detected at levels greater than the MDL, the source(s) of contamination should be identified and corrected, the affected batch of bottles or equipment should be re-cleaned, and new equipment blanks should be prepared and analyzed.

Bottle blanks will consist of one of each type of sample container required for water quality analyses, selected randomly from the set of available bottles. The bottles will be filled with laboratory-prepared blank water (acidified to pH < 2 for metals samples) and allowed to stand for a minimum of 24 hours before analysis.

Sampler blanks will consist of laboratory-prepared blank water processed through the sampling equipment using the same procedures used for environmental samples.

Note that these procedures will not be necessary if grab samples are collected by direct submersion of sample bottles, without intermediate sampling equipment.

<u>Method Blanks</u>

The purpose of analyzing method blanks is to demonstrate that the analytical procedures do not result in sample contamination. Method blanks will be prepared and analyzed by the contract laboratory at a rate of at least one for each analytical batch. Method blanks will consist of laboratory-prepared blank water processed along with the batch of environmental samples. The method blank should be prepared and analyzed before analysis of the associated environmental samples. If the result for a single method blank is greater than the MDL, or if the average blank concentration plus two standard deviations of three or more blanks is greater than the RL, the source(s) of contamination should be corrected, and the associated samples should be reanalyzed. If reanalysis is not possible, the associated sample results should be qualified as an *upper limit* (UL) at the reported value.

<u>Laboratory Control Samples</u>

The purpose of analyzing laboratory control samples is to demonstrate the accuracy of the analytical method. Laboratory control samples will be analyzed at the rate of one per sample batch. Laboratory control samples will consist of laboratory fortified method blanks. If recovery of any analyte is outside the acceptable range for accuracy, the analytical process is not being performed adequately for that analyte. In this case, the sample batch should be prepared again, and the laboratory control sample should be reanalyzed. If reanalysis is not possible, the associated sample results should be qualified as *low or high biased*.

<u>Laboratory Duplicates</u>

The purpose of analyzing laboratory duplicates is to demonstrate the precision of the analytical method. Laboratory duplicates will be analyzed at the rate of one pair per sample batch. Laboratory duplicates will consist of duplicate laboratory fortified method blanks. If the RPD for any analyte is greater than the precision criterion *and* the absolute difference between duplicates is greater than the RL, the analytical process is not being performed adequately for that analyte. In this case, the sample batch should be prepared again, and laboratory duplicates should be reanalyzed. If reanalysis is not possible, the associated sample results should be qualified as *not reproducible* due to analytical variability.

Matrix Spikes and Matrix Spike Duplicates

The purpose of analyzing matrix spikes and matrix spike duplicates is to demonstrate the performance of the analytical method in a particular sample matrix. Matrix spikes and matrix spike duplicates will be analyzed at the rate of one pair per sample batch. Each matrix spike and matrix spike duplicate will consist of an aliquot of laboratory-fortified environmental sample. Spike concentrations should be added at between 2 to 10 times the expected sample value.
If matrix spike recovery of any analyte is outside the acceptable range, the results for that analyte have failed the acceptance criteria. If recovery of laboratory control samples is acceptable, the analytical process is being performed adequately for that analyte, and the problem is attributable to the sample matrix. Attempt to correct the problem (by dilution, concentration, etc.) and re-analyze the samples and the matrix spikes. If the matrix problem can't be corrected, qualify the results for that analyte as appropriate (*low or high biased*) due to matrix interference.

If matrix spike duplicate RPD for any analyte is greater than the precision criterion, the results for that analyte have failed the acceptance criteria. If the RPD for laboratory duplicates is acceptable, the analytical process is being performed adequately for that analyte, and the problem is attributable to the sample matrix. Attempt to correct the problem (by dilution, concentration, etc.) and re-analyze the samples and the matrix spike duplicates. If the matrix problem can't be corrected, qualify the results for that analyte as *not reproducible*, due to matrix interference.

Aquatic Toxicity Quality Control

For aquatic toxicity tests, the acceptability of test results is determined primarily by performance-based criteria for test organisms, culture and test conditions, and the results of control bioassays. Control bioassays include testing with reference toxicants, and negative and solvent controls.

In addition to the QA requirements for the toxicity testing methods, a minimum of ten percent of the samples collected for aquatic toxicity testing will be reserved for other QC analyses. These analyses will consist of interlaboratory splits, field duplicates, or spiked samples. At least one laboratory split analyses will be performed during the monitoring year, *if possible*. If no appropriate laboratories are willing to perform these analyses at a reasonable cost, these QA samples will be analyzed as field duplicates by Aqua Science. Field duplicate samples analyzed for aquatic toxicity will also serve as field duplicates for alkalinity and hardness analyses. Although the laboratory has no formal limit of acceptability for analysis of spiked samples, the pattern and progress of toxic responses are evaluated subjectively for consistency with expected responses for the level of the spiked compound. Acceptable results for tests with blanks are no significant toxicity.

Table B-9a. Project Quality Control Requirements for Analysis of Water Quality Samples: Frequency[1] and Numbers of Field Quality Assurance Samples for Mercury, Organic Carbon, General Water Quality Constituents, Pesticides, and Pathogen Indicators.

Parameter(s)	Field Duplicates	Field Blanks	Total QA Samples
Mercury	12 (1 per event)	12 (1 per event)	24
Methylmercury	12 (1 per event)	12 (1 per event)	24
Hardness	6 (1 per event)	0	6
TOC and DOC	6 (1 each per event)	6 (1 per event)	12
Color	6 (1 per event)	0	6
TSS	6 (1 per event)	0	6
TDS	6 (1 per event)	0	6
Nitrate	6 (1 per event)	6 (1 per event)	12
OP Pesticides	6 (1 per event)	6 (1 per event)	12
Carbamate Pesticides	6 (1 per event)	6 (1 per event)	12
Chlorinated Pesticides	6 (1 per event)	6 (1 per event)	12
Trace Metals	6 (1 per event)	6 (1 per event)	12
Fecal coliform	12 (1 per event)	12 (1 per event)	24

(1) External QA samples are rotated among sites to provide at least one field duplicate sample and one field blank per event for a particular parameter (as appropriate for specific analyses).

Table B-9b. Project Quality Control Requirements for Analysis of Water Quality Samples: Trace Metals, Organic Carbon, and General Water Quality Constituents.

QA Procedure	QA Parameter	Frequency[1]	Criterion	Corrective Action
Equipment Blanks: • bottle blanks • sampler blanks	Contamination	1 per bottle lot, reagent lot, or equipment lot	< MDL	Identify contamination source. Reclean equipment. Reanalyze blank(s).
Field Blanks	Contamination	Various, see Table B-8a	< RL *or* < sample ÷ 5	Examine field log. Identify contamination source. Qualify data as needed.
Field Duplicate	Precision	Various, see Table B-8a	RPD ≤ 25% if |Difference| ≥ RL	Reanalyze both samples. Identify variability source. Qualify data as needed.
Method Blank	Contamination	≥1 per batch, (trace metals and OC)	< MDL *or*, if n≥3, avg ± 2 s.d. < RL	Identify contamination source. Reanalyze method blank and all samples in batch.
LCS or SRM	Accuracy	1 per batch	80-120% REC	Recalibrate and reanalyze LCS or SRM and samples
Lab Duplicate	Precision	1 per batch	RPD ≤ 20% if |Difference| ≥ RL	Recalibrate and reanalyze.
Matrix Spike	Accuracy	1 per batch	80-120% REC	Check SRM recovery. Attempt to correct matrix problem and reanalyze sample. Qualify data as needed.
Matrix Spike Duplicate	Precision	1 per batch	RPD ≤ 20%	Check lab dup RPD. Attempt to correct matrix problem and reanalyze samples. Qualify data as needed.
Assess percent of data successfully collected	Data Completeness	1 per event	90%	Reschedule sample events as necessary or appropriate.

Notes: MDL = Method Detection Limit; RL = Reporting Limit; RPD = Relative Percent Difference; RSD = Relative Standard Deviation; REC = Recovery; LCS = Laboratory Control Sample; SRM = Standard Reference Material (=Certified Reference Material)

(1) The term “lot” refers to a set of bottles or reagents identifiable by a common production lot number, or to sampling equipment subjected to the same cleaning procedures as a set.
The term “batch”, as used in this document, refers to an uninterrupted series of analyses.

Table B-9c. Project Quality Control Requirements for Analysis of Water Quality Samples: Requirements for Chlorinated Pesticide Analyses by EPA Method 608.

QA Procedure	QA Parameter	Frequency[1]	Criterion	Corrective Action
Equipment Blanks: • bottle blanks • sampler blanks	Contamination	1 per bottle or reagent lot	< MDL	Identify contamination source. Reclean equipment. Reanalyze blank(s).
Field Blanks	Contamination	1 per event	< RL *or* < (sample ÷ 5)	Examine field log. Identify contamination source. Qualify data as needed.
Field Duplicate	Precision	1 per event	RPD ≤ 25% if |Difference| ≥ RL	Reanalyze both samples. Identify variability source. Qualify data as needed.
Matrix Spike & LCS	Accuracy	1 per batch	 28-163% REC 60-117% REC 60-150% REC 76-140% REC	Check SRM recovery. Attempt to correct matrix problem and reanalyze sample. Qualify data as needed.
Matrix Spike & LCS Duplicates: BHC-alpha isomer BHC-beta isomer Cis-Chlordane Dieldrin Endrin Heptachlor epoxide Heptachlor Hexachlorobenzene (HCB) Lindane o,p'-DDD o,p'-DDE o,p'-DDT p,p'-DDD p,p'-DDE p,p'-DDT Trans-chlordane	Precision	1 per batch	 31% RPD 25% RPD	Check lab dup RPD. Attempt to correct matrix problem and reanalyze samples. Qualify data as needed.
Assess percent of data successfully collected	Data Completeness	1 per event	90%	Reschedule sample events as necessary or appropriate.

Notes: MDL = Method Detection Limit; RL = Reporting Limit; RPD = Relative Percent Difference; RSD = Relative Standard Deviation; REC = Recovery; LCS = Laboratory Control Sample; SRM = Standard Reference Material (=Certified Reference Material)

(1) The term “lot” refers to a set of bottles or reagents identifiable by a common production lot number, or to sampling equipment subjected to the same cleaning procedures as a set.
The term “batch”, as used in this document, refers to an uninterrupted series of analyses.

Table B-9d. Project Quality Control Requirements for Analysis of Water Quality Samples: Requirements for Organophosphorus Pesticide Analyses by EPA Method 614.

QA Procedure	QA Parameter	Frequency[1]	Criterion	Corrective Action
Equipment Blanks: • bottle blanks • sampler blanks	Contamination	1 per bottle or reagent lot	< MDL	Identify contamination source. Reclean equipment. Reanalyze blank(s).
Field Blanks	Contamination	1 per event	< RL *or* < (sample ÷ 5)	Examine field log. Identify contamination source. Qualify data as needed.
Field Duplicate	Precision	1 per event	RPD ≤ 25% if |Difference| ≥ RL	Reanalyze both samples. Identify variability source. Qualify data as needed.
Matrix Spike & LCS Phorate Diazinon Disulfoton Methyl Parathion Stirophos Ethion Tributylphosphate Triphenlyphosphate	Accuracy	1 per batch	 22-96% REC 57-130% REC 47-117% REC 55-164% REC 68-128% REC 65-134% REC 60-150% REC 76-140% REC	Check SRM recovery. Attempt to correct matrix problem and reanalyze sample. Qualify data as needed.
Matrix Spike & LCS Duplicates: Phorate Diazinon Disulfoton Methyl Parathion Stirophos Ethion	Precision	1 per batch	 24% RPD 21% RPD 22% RPD 24% RPD 25% RPD 20% RPD	Check lab dup RPD. Attempt to correct matrix problem and reanalyze samples. Qualify data as needed.
Assess percent of data successfully collected	Data Completeness	1 per event	90%	Reschedule sample events as necessary or appropriate.

Notes: MDL = Method Detection Limit; RL = Reporting Limit; RPD = Relative Percent Difference; RSD = Relative Standard Deviation; REC = Recovery; LCS = Laboratory Control Sample; SRM = Standard Reference Material (=Certified Reference Material)

(1) The term “lot” refers to a set of bottles or reagents identifiable by a common production lot number, or to sampling equipment subjected to the same cleaning procedures as a set.
The term “batch”, as used in this document, refers to an uninterrupted series of analyses.

Table B-9e. Project Quality Control Requirements for Analysis of Water Quality Samples: Requirements for Carbamate Pesticide Analyses by EPA Method 632.

QA Procedure	QA Parameter	Frequency[1]	Criterion	Corrective Action
Equipment Blanks: • bottle blanks • sampler blanks	Contamination	1 per bottle or reagent lot	< MDL	Identify contamination source. Reclean equipment. Reanalyze blank(s).
Field Blanks	Contamination	1 per event	< RL *or* < (sample ÷ 5)	Examine field log. Identify contamination source. Qualify data as needed.
Field Duplicate	Precision	1 per event	RPD ≤ 25% if |Difference| ≥ RL	Reanalyze both samples. Identify variability source. Qualify data as needed.
Matrix Spike & LCS Methomyl Bromacil Neburon Oryzalin	Accuracy	1 per batch	 37-113% REC 58-111% REC 55-132% REC 40-140% REC	Check SRM recovery. Attempt to correct matrix problem and reanalyze sample. Qualify data as needed.
Matrix Spike & LCS Duplicates: Methomyl Bromacil Neburon	Precision	1 per batch	 25% RPD 25% RPD 25% RPD	Check lab dup RPD. Attempt to correct matrix problem and reanalyze samples. Qualify data as needed.
Assess percent of data successfully collected	Data Completeness	1 per event	90%	Reschedule sample events as necessary or appropriate.

Notes: MDL = Method Detection Limit; RL = Reporting Limit; RPD = Relative Percent Difference; RSD = Relative Standard Deviation; REC = Recovery; LCS = Laboratory Control Sample; SRM = Standard Reference Material (=Certified Reference Material)

(1) The term “lot” refers to a set of bottles or reagents identifiable by a common production lot number, or to sampling equipment subjected to the same cleaning procedures as a set.
The term “batch”, as used in this document, refers to an uninterrupted series of analyses.

Table B-9f. Project Quality Control Requirements for Analysis of Water Quality Samples for Pathogens and Pathogen Indicators.

QA Procedure	Parameter	Frequency[1]	Criterion	Corrective Action
Field Blanks	Contamination	1 per event	< RL *or* < sample ÷ 5	Examine field log. Identify contamination source. Qualify data as needed.
Method Blanks (Sterility Checks)	Contamination	1 per batch	< RL	Identify contamination source. Clean equipment and slides. Check reagents. Re-analyze blank.
Lab Duplicate	Precision[2]	1 per 10 samples, and at least 1 per batch	$R_{log} \leq 3.27 \cdot$mean R_{Log}	Recalibrate and reanalyze.
Negative Control Samples	Contamination	1 per culture medium or reagent lot	< RL	Identify source. Clean equipment and prepare new media. Re-examine negative control
Positive Control Samples	Assay function	1 per culture medium or reagent lot	≥ RL	Identify and correct problem. Re-examine positive control.
Assess percent of data successfully collected	Data Completeness	1 per planned sample event	90%	Reschedule sample events as necessary or appropriate.

Notes: MDL = Method Detection Limit; RL = Reporting Limit; RPD = Relative Percent Difference; RSD = Relative Standard Deviation; REC = Recovery; LCS = Laboratory Control Sample; SRM = Standard Reference Material (=Certified Reference Material)

(1) The method documentation defines an analytical batch as an "uninterrupted series of analyses".

(2) R_{log} is the absolute difference between logarithms of coliform counts for duplicate analyses. The mean R_{log} is determined by performing duplicate analyses on the first 15 positive sample analyzed for each matrix type.

Table B-9g. Project Quality Control Requirements for Analysis of Water Quality Samples: Requirements for Field Measurements.

QA Procedure	QA Parameter	Frequency[1]	Criterion	Corrective Action
Field Duplicate	Precision	1 per event	RPD ≤ 25%	Reanalyze both samples. Identify variability source. Qualify data as needed.
Assess percent of data successfully collected	Data Completeness	1 per event	95%	Reschedule sample events as necessary or appropriate.

Notes: RPD = Relative Percent Difference;

Table B-10. Project Quality Control Schedule

SITE	EVENTS Nov **1**	 Dec **2**	 Jan **3**	 Feb **4**	 March **5**	 April **6**	 May **7**	 June **8**	 July **9**	 Aug **10**	 Sept **11**	 Oct **12**
1												
2	FB/FD									MS/MSD		
3		FB/FD							MS/MSD			
4			FB/FD					MS/MSD				
5				FB/FD			MS/MSD					
6					FB/FD	MS/MSD					MS/MSD	
7					MS/MSD	FB/FD					FB/FD	
8												
9				MS/MSD			FB/FD					
10			MS/MSD					FB/FD				
11		MS/MSD							FB/FD			MS/MSD
12	MS/MSD									FB/FD		FB/FD

FB = Field Blank

FD = Field Duplicate

MS/MSD = Matrix Spike/Matrix Spike Duplicate

5.4 Sample Equipment Cleaning Procedures

Equipment used for sample collection (peristaltic pump tubing, carboys and carboy caps, and sample bottles) will be cleaned according to the specific procedures documented for each analytical method.

A minimum of one equipment blank will be generated and analyzed for mercury and methylmercury prior to initiating monitoring for the current program year, and additional equipment blanks will be analyzed for new lots of critical cleaning reagents. In addition, for all analytes where contamination is considered a significant concern, field blanks will be collected and analyzed as directed in Section B-5 of this document. If the results of these analyses indicate any contamination, the source will be identified and corrected, and the equipment will be re-cleaned and re-tested. The combined regimen of equipment blanks and field blanks is considered to provide adequate control against potential systematic equipment contamination problems.

5.5 Analytical Instrument and Equipment Testing Procedures and Corrective Actions

Testing, inspection, maintenance of analytical equipment used by the contract laboratory, and corrective actions are documented in the Quality Assurance manuals for each analyzing laboratory. Laboratory QA Manuals are made available for review at the analyzing laboratory.

6. Calibration Procedures and Frequency

6.1 Laboratory Analytical Equipment

Frequency and procedures for calibration of analytical equipment used by each contract laboratory is documented in the Quality Assurance Manual for each contract laboratory. Laboratory QA Manuals are made available for review at the analyzing laboratory.

6.2 Field Instruments

Calibration of all instruments used for measurement of field parameters (temperature, pH, dissolved oxygen, and electroconductivity) are performed as described in the owner's manuals for individual instruments. Instruments used to measure pH, dissolved oxygen, and electroconductivity should be calibrated prior to taking field measurements at each site for each event. Typical field instrument calibration procedures are as follows:

- Temperature calibration is factory-set and requires no subsequent calibration.
- Calibration for pH measurement is accomplished using standard buffer solutions.
- Calibration for dissolved oxygen measurements is accomplished using an oxygen-saturated water sample.
- Calibration for electroconductivity measurements is generally accomplished using potassium chloride standard solutions.

7. Inspection/Acceptance Requirements for Supplies and Consumables

Gloves, sample containers, and any other consumable equipment used for sampling will be inspected by the sampling crew on receipt and will be rejected/returned if any obvious signs of contamination (torn packages, etc.) are observed. Inspection protocols and acceptance criteria for laboratory analytical reagents and other consumables are documented in the Quality Assurance Manuals for individual laboratories. Laboratory QA Manuals are made available for review at the analyzing laboratories.

8. Quality Control Requirements for Indirect Measurements

Water quality data collected by this monitoring program is intended to complement data collected by several other programs, including NAWQA, and receiving water monitoring conducted by the City of Woodland, the City of Davis, and the University of California at Davis.

9. Data Management

Copies of field logs, copies of chain of custody forms, original preliminary and final lab reports, and electronic media reports will be sent to the Quality Assurance Manager. Each type of report will be stored separately and ordered chronologically. The field crew will retain original field logs. The contract laboratory will retain original chain of custody forms. The contract laboratory(s) will retain copies of the preliminary and final data reports.

Concentrations of chemicals and toxicity endpoints, and all numerical biological parameters will be calculated as described in the laboratory Standard Operating Procedures or referenced method document for each analyte or parameter.

The various data and information generated from the Yolo Bypass Monitoring Program will be stored and maintained at the Monitoring Program Manager’s offices (Larry Walker Associates). The data generated from the monitoring program will be transmitted to the Quality Assurance Manager in various formats and converted to a standard database format maintained on personal computers in the Monitoring Program Manager’s office. After data entry or data transfer procedures are completed for each sample event, data will be inspected for data transcription errors, and corrected as appropriate. After the final QA checks for errors are completed, the data are added to the final database. Data tables are generated from this database.

In cases where environmental results are less than the reporting limit for a parameter, the results will be reported as “less than” the reporting limit; e.g. an analytical result of 4 μg/L for an analyte with a reporting limit of 5 μg/L will be reported as <5 μg/L.
In cases where field blank results exceed the acceptance criteria listed in Table B-0.1, data collected during the associated sample run will be qualified and reported as follows:

- Measured environmental sample concentrations greater than or equal to 5 times the field blank level will be reported with no qualification.

- Measured environmental sample concentrations less than 5 times the field blank level will be qualified as “less than” the measured value, e.g. if a field blank is equal to 1.5 µg/L, a measured environmental concentration of 4.0 µg/L will be reported as <4.0 µg/L.
- Any data qualifications resulting from QC analyses will be reported with the environmental data as appropriate.

C. ASSESSMENT AND OVERSIGHT

1. Assessments and Response Actions

Assessments of compliance with quality control procedures will be undertaken on a routine basis during the data collection phase of the project:

- Performance assessments of sampling procedures will be performed by the field sampling crews. Corrective actions shall be carried out by the field sampling crew and reported to the Quality Assurance Manager.
- Assessment of laboratory QC results and implementation of corrective actions will be the responsibility of the QA officer at each laboratory and shall be reported to the Quality Assurance Manager as part of any data reports.
- Assessment of field QC results and implementation of corrective actions shall be the responsibility of the Quality Assurance Manager.

Routine procedures to assess precision and accuracy, criteria for success, and corrective actions have been discussed previously (Section B) and are summarized in Table B-9a through B-9f.

Monthly status reports will be produced by the Monitoring Program Manager to document project status, results of performance evaluations, data quality assessments, and any significant QA problems and recommended solutions. Monthly status reports will be distributed to the Project Manager and the CalFed liaison officer.

2. Quality Assurance Reports to Management

On completion of the monitoring season, a quality assurance report will be prepared by the Quality Assurance Manager, as part of the annual report produced for the Yolo Bypass. The quality assurance report will summarize the results of QA/QC assessments and evaluations, including precision, accuracy, comparability, representativeness, and completeness of the monitoring data. The annual report will be distributed to the project managers, stakeholder group members, and interested parties.

D. DATA VALIDATION AND USABILITY

1. Data Review, Validation, and Verification

In addition to the data quality objectives presented in Tables B-9a through B-9f, the standard data validation procedures documented in the contract laboratory's Quality Assurance Manuals will be used to accept, reject, or qualify the data generated by the laboratory. Laboratory's QA officer will be responsible for validating data generated by the laboratory. The field monitoring coordinator will be responsible for initial verification of data submitted by analyzing labs, including electronic data reports. The Quality Assurance Manager will be responsible for final validation and for qualifying all data based on the evaluation of field and laboratory quality control samples.

Mercury and methyl-mercury data shall be reviewed to evaluate whether the data are reasonable; i.e, methyl-mercury concentrations should not exceed the corresponding total mercury concentrations.

2. Data Reporting

Laboratory personnel will verify that the measurement process was "in control" (i.e., all specified data quality objectives were met or acceptable deviations explained) for each batch of samples before proceeding with the analysis of a subsequent batch. In addition, each laboratory will establish a system for detecting and reducing transcription and/or calculation errors prior to reporting data.

The laboratory will only consider submitted data that have met data quality objectives, or have acceptable deviations explained. When QA requirements have not been met, the samples will be reanalyzed when possible and only the results of the reanalysis will be submitted, provided they are acceptable.

For mercury and methyl-mercury, all laboratory QA information will be reported along with the analytical results.

E. REFERENCES

APHA, AWWA, and WEF 1995. Standard Methods for the Examination of Water and Wastewater, 19th Edition. American Public Health Association (APHA), American Waterworks Association (AWWA), and Water Environment Association (WEF). Washington, DC.

USEPA 1979. Handbook for Analytical Quality Control in Water and Wastewater Laboratories. U.S. Environmental Protection Agency (USEPA). EPA 600-4-79-019.

USEPA 1979. Methods for Chemical Analysis of Water and Wastes (EPA 600-4-79-020). U.S. Environmental Protection Agency (USEPA).

USEPA 1994. Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms (EPA 600/4-91-002). U.S. Environmental Protection Agency (USEPA), Office of Research and Development. July 1994.

USEPA 1995. Guidance on the Documentation and Evaluation of Trace Metals Data Collected for Clean Water Act Compliance Monitoring. EPA 821-B-95-002. U.S. Environmental Protection Agency, Office of Water, Washington DC.

USEPA 1995. Method 1631: Mercury in Water by Oxidation, Purge and Trap, and Cold Vapor Atomic Fluorescence Spectrometry. U.S. Environmental Protection Agency (USEPA), Office of Water. EPA 821-R 95-027.

USEPA 1995. Method 1669: Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels. U.S. Environmental Protection Agency (USEPA), Office of Water. EPA 821-R-95-034.

USEPA 2001. Method 1630 (*DRAFT*): Methyl Mercury in Water by Distillation, Aqueous Purge and Trap, and CVAFS. EPA-821-R-01-020. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

APPENDIX 6. PROJECT MONITORING RESULTS AND SUMMARY STATISTICS

Appendix 6-A. Analytical Results for Samples Collected During the Study Period

Water Column Samples

Electrical Conductivity (uS/cm)

Site #	Sampling Site	Results											
		NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JLY	AUG	SEP	OCT
1	Fremont Weir				158								
2	Ridge Cut	491	491	569	319	826	731	923	985	1109	964	888	688
3	Cache Creek	562	570	585	334	602	741	470	280	675	555	802	570
4	Willow Slough Bypass	1596	1352	1120	608	1107	890	640	812	925	1267	917	775
5	YB Wildlife Area	760	615	560			603	664	592	361	732	920	830
6	Putah Creek	611	522	514	359	365	853	504	480	472	541	651	421
7	Z Drain	610	764	797	790	1087	996	447	411	415	540	595	538
8	Sacramento Weir				81								
9	Woodland R1	513	520	578	80	916	498	564	668	634	545	541	665
10	Woodland R2	896	485	560	158	789	603	770	817	842	614	640	878
11	Tule Canal @ 80	686	530	620	210	615	702	895	760	823	840	827	752
12	Toe Drain	827		590		479	514	310	210	193	278	1013	260

Hardness (mg/l)

Site #	Sampling Site	Results					
		NOV	JAN	APR	JUN	AUG	SEPT
2	Ridge Cut	180	190	270	390	660	280
3	Cache Creek	230	240	300	140	260	340
4	Willow Slough Bypass	390	400	330	260	390	310
6	Putah Creek	220	270	220	280	250	240
11	Tule Canal @ 80	200	220	190	290	280	250
12	Toe Drain	240	210	230	100	160	310

Total Organic Carbon (mg/l)

Site #	Sampling Site	Results					
		NOV	JAN	APR	JUN	AUG	SEP
2	Ridge Cut	4	9	10	4	5	5
3	Cache Creek	3	3	5	3	4	8
4	Willow Slough Bypass	8	15	8	8	11	12
6	Putah Creek	2	5	6	5	4	10
11	Tule Canal @ 80	4	9	8	7	9	9
12	Toe Drain	11	7	6	5	8	11

Dissolved Organic Carbon (mg/l)

Site #	Sampling Site	Results					
		NOV	JAN	APR	JUN	AUG	SEP
2	Ridge Cut	4	8	9	4	9	8
3	Cache Creek	ND	6	4	4	6	10
4	Willow Slough Bypass	7	7	7	8	9	13
6	Putah Creek	ND	4	5	4	6	6
11	Tule Canal @ 80	6	7	7	6	8	9
12	Toe Drain	10	8	8	4	6	9

Color (cu)

Site #	Sampling Site	Results					
		NOV	JAN	APR	JUN	AUG	SEP
2	Ridge Cut	70	85	85	150	140	200
3	Cache Creek	35	40	28	120	70	250
4	Willow Slough Bypass	100	40	50	130	200	17
6	Putah Creek	20	15	12	80	20	400
11	Tule Canal @ 80	70	70	80	130	60	200
12	Toe Drain	60	65	50	170	160	400

Total Dissolved Solids (mg/l)

Site #	Sampling Site	Results					
		NOV	JAN	APR	JUN	AUG	SEP
2	Ridge Cut	340	370	390	680	650	570
3	Cache Creek	340	350	380	200	360	520
4	Willow Slough Bypass	880	740	440	500	710	650
6	Putah Creek	330	330	250	270	250	360
11	Tule Canal @ 80	460	360	290	570	460	480
12	Toe Drain	440	360	330	190	180	580

Total Suspended Solids (mg/l)

Site #	Sampling Site	Results					
		NOV	JAN	APR	JUN	AUG	SEP
2	Ridge Cut	69	46	76	88	80	46
3	Cache Creek	46	40	25	62	16	18
4	Willow Slough Bypass	53	40	58	32	64	110
6	Putah Creek	ND	9	12	14	8	3
11	Tule Canal @ 80	42	50	80	80	38	58
12	Toe Drain	37	66	52	96	36	62

Fecal Coliform (MPN/100ml)

Site #	Sampling Site	Results											
		NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JLY	AUG	SEP	OCT
1	Fremont Weir				3000								
2	Ridge Cut	20	<20	2	2800	<20	20	3000	1300	50	1700	90	50
3	Cache Creek	70	40	50	34	20	20	3000	80	1300	50	1700	5000
4	Willow Slough Bypass	1400	50000	17000	4000	40	70	1400	3000	13000	3000	17000	2400
5	YB Wildlife Area	20	20	50			40	40	80	60	30		2200
6	Putah Creek	20	20	50	70	1100	40	1700	1100	90	230	1700	23
7	Z Drain	80	5000	50	2400	20	11000	6000	5000	5000	30000	14000	50
8	Sacramento Weir				9000								
9	Woodland R1	1300	20	30	16000	40	20	8000	1300	50	3000	2200	50
10	Woodland R2	1700	40	70	17000	70	20	1700	1100	80	2400	1000	2400
11	Tule Canal @ 80	80	20	17	5000	9000	20	2200	80	50	1700	5000	1100
12	Toe Drain	40		1100		17000	<20	40	23	50	30	50	5000

***E. Coli* (MPN/100ml)**

Site #	Sampling Site	Results											
		NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JLY	AUG	SEP	OCT
1	Fremont Weir				3000								
2	Ridge Cut	20	<20	2	2,800	<20	20	3,000	1,300	50	30	60	50
3	Cache Creek	70	40	17	34	20	20	3,000	22	1,300	50	1,700	5,000
4	Willow Slough Bypass	1,400	50,000	1,700	4,000	40	70	1,400	1,700	8,000	3,000	8,000	11,000
5	YB Wildlife Area	20	20	50			40	20	80	60	17		30
6	Putah Creek	20	20	30	70	1,100	40	1,700	30	50	13	8	23
7	Z Drain	80	5,000	21	2,400	20	11,000	6,000	5,000	5,000	30,000	9,000	50
8	Sacramento Weir				5,000								
9	Woodland R1	1,300	20	30	16,000	40	20	5,000	22	50	27	1,700	50
10	Woodland R2	1,700	20	50	17,000	70	20	1,700	70	80	17	1,000	80
11	Tule Canal @ 80	80	20	11	3,000	900	20	2,200	80	30	80	50	1,100
12	Toe Drain	40		1,100		17,000	<20	40	23	50	30	50	2,200

Total Coliform (MPN/100ml)

Site #	Sampling Site	Results											
		NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JLY	AUG	SEP	OCT
1	Fremont Weir				500								
2	Ridge Cut	2,700	17,000	21	1,600	17,000	17,000	17,000	3,000	3,000	3,000	3,000	3,000
3	Cache Creek	8,000	7,000	2,200	1,200	600	5,000	17,000	3,000	3,000	3,000	3,000	17,000
4	Willow Slough Bypass	30,000	50,000	9,000	160,000	11,000	3,000	80,000	1,400	1,400	1,400	1,400	50,000
5	YB Wildlife Area	2,300	1,700	1,100			3,000	3,000	40	40	40		50,000
6	Putah Creek	40	1,700	80	3,500	8,000	8,000	24,000	1,700	1,700	1,700	1,700	3,000
7	Z Drain	8,000	17,000	1,700	3,000	13,000	17,000	220,000	6,000	6,000	6,000	6,000	90,000
8	Sacramento Weir				11,000								
9	Woodland R1	3,000	2,600	1,400	300,000	5,000	5,000	160,000	8,000	8,000	8,000	8,000	5,000
10	Woodland R2	5,000	1,700	1,100	900,000	9,000		17,000	1,700	1,700	1,700	1,700	5,000
11	Tule Canal @ 80	8,000	3,000	9,000	17,000	170,000	3,000	33,000	2,200	2,200	2,200	2,200	16,000
12	Toe Drain	1,700		170,000		160,000	3,000	24,000	40	40	40	40	16,000

TOTAL ALUMINUM (ug/L)

Site #	Sampling Site	Results					
		NOV	JAN	APR	JUN	AUG	SEPT
2	Ridge Cut	1200	1500	2200	3300	2100	700
3	Cache Creek	1800	700	800	2800	1200	500
4	Willow Slough Bypass	1600	800	1800	1800	2400	4100
6	Putah Creek	110	230	450	1800	140	70
11	Tule Canal @ 80	1800	1700	3000	2800	1300	1800
12	Toe Drain	1600	2600	2300	6000	3200	2800

DISSOLVED ALUMINUM (ug/l)

Site #	ampling Si	Results					
		NOV	JAN	APR	JUN	AUG	SEPT
2	Ridge Cut	-10	20	20	-10	-10	-10
3	Cache Cre	-10	-10	10	20	-10	-10
4	Willow Slo	-10	-10	10	-10	-10	-10
6	Putah Cree	-10	-10	10	-10	-10	-10
11	Tule Canal	-10	10	10	-10	-10	-10
12	Toe Drain	-10	20	20	20	20	-10

TOTAL BORON (ug/L)

Site #	Sampling Site	Results					
		NOV	JAN	APR	JUN	AUG	SEPT
2	Ridge Cut	250	200	910	2700	2400	1000
3	Cache Creek	1700	1400	1700	550	1200	2300
4	Willow Slough Bypass	1300	1700	1400	1400	1400	1500
6	Putah Creek	350	400	390	1400	840	510
11	Tule Canal @ 80	1100	800	550	1700	1100	1000
12	Toe Drain	1700	700	550	140	170	1700

DISSOLVED BORON (ug/l)

Site #	ampling Si	Results					
		NOV	JAN	APR	JUN	AUG	SEPT
2	Ridge Cut	260	200	880	2,700	2,200	1,400
3	Cache Cre	1,600	1,300	1,700	490	1,200	2,400
4	Willow Slo	1,300	1,500	1,300	1,300	1,400	1,400
6	Putah Cree	340	400	360	430	390	500
11	Tule Canal	1,000	700	530	1,500	1,100	1,000
12	Toe Drain	800	700	510	130	140	1,700

Nitrate as N (mg/l)

Site #	Sampling Site	Results					
		NOV	JAN	APR	JUN	AUG	SEPT
2	Ridge Cut	0	1.1	0	2	0	0
3	Cache Creek	0.8	5.4	2	0	0	1
4	Willow Slough Bypass	0.3	0.3	0	1	0	1
6	Putah Creek	1.3	1.3	2	1	1	1
11	Tule Canal @ 80	1.0	0.3	1	1	1	1
12	Toe Drain	0.2	0.8	1	0	0	3

TOTAL CHROMIUM(III) (ug/L)

Site #	Sampling Site	Results					
		NOV	JAN	APR	JUN	AUG	SEPT
3	Cache Creek	9	3.8	6.2	13	6.6	2.7
6	Putah Creek	4	4.4	6	6.2	2.3	2.8
2	Ridge Cut	4	4.1	8	15	8.5	8.9
12	Toe Drain	8	8.3	8.6	19	12	6.0
11	Tule Canal @ 80	7	5.7	10	10	5.3	1.1
4	Willow Slough Bypass	7	2.7	6.3	5.9	10	14

DISSOLVED CHROMIUM(III) (ug/l)

Site #	ampling Si	Results					
		NOV	JAN	APR	JUN	AUG	SEPT
2	Ridge Cut	0.4	1.0	1.2	2.5	0.9	0.8
3	Cache Cre	1.2	2.2	3.4	1.1	1.4	1.1
4	Willow Slo	1.6	2.2	1.5	1.4	2.9	1.2
6	Putah Cree	4.0	4.8	4.5	3.1	1.6	1.9
11	Tule Canal	0.5	2.1	1.3	1.2	1.7	0.6
12	Toe Drain	0.8	1.3	1.7	1.1	1.0	0.8

TOTAL COPPER (ug/L)

Site #	Sampling Site	Results					
		NOV	JAN	APR	JUN	AUG	SEPT
2	Ridge Cut	4	5.9	8	9	7	3
3	Cache Creek	5	3.5	3	8	5	3
4	Willow Slough Bypass	7	4.6	5	5	9	11
6	Putah Creek	2	1.8	3	5	2	2
11	Tule Canal @ 80	8	6	9	9	6	6
12	Toe Drain	5	7.4	7	12	8	9

DISSOLVED COPPER (ug/l)

Site #	ampling Si	Results					
		NOV	JAN	APR	JUN	AUG	SEPT
2	Ridge Cut	2.4	2.5	3.6	2.2	2.5	2.0
3	Cache Cre	1.4	1.6	1.3	1.7	1.8	2.3
4	Willow Slo	3.4	3.2	1.7	1.8	3.3	2.8
6	Putah Cree	1.9	1.7	1.5	1.6	1.7	1.4
11	Tule Canal	3.1	2.5	2.5	2.7	2.4	2.3
12	Toe Drain	2.4	2.8	2.7	2.5	2.8	4.5

TOTAL LEAD (ug/L)

Site #	Sampling Site	Results					
		NOV	JAN	APR	JUN	AUG	SEPT
2	Ridge Cut	0.53	0.98	1	2	1	0
3	Cache Creek	0.70	0.40	0	2	1	1
4	Willow Slough Bypass	0.83	0.53	1	1	2	2
6	Putah Creek	0	0	0	1	0	0
11	Tule Canal @ 80	0.91	0.91	1	1	1	1
12	Toe Drain	0.65	1.3	1	2	1	1

DISSOLVED LEAD (ug/l)

Site #	ampling Si	Results					
		NOV	JAN	APR	JUN	AUG	SEPT
2	Ridge Cut	-0.3	-0.3	0.3	-0.25	-0.25	0.25
3	Cache Cre	-0.3	-0.3	0.3	-0.25	-0.25	-0.25
4	Willow Slo	-0.3	-0.3	0.3	-0.25	-0.25	-0.25
6	Putah Cree	-0.3	-0.3	0.3	-0.25	-0.25	-0.25
11	Tule Canal	-0.3	-0.3	0.3	-0.25	-0.25	-0.25
12	Toe Drain	-0.3	-0.3	0.3	-0.25	-0.25	-0.25

TOTAL SELENIUM (ug/L)

Site #	Sampling Site	Results					
		NOV	JAN	APR	JUN	AUG	SEPT
2	Ridge Cut	1	-1	2	5	5	2
3	Cache Creek	1	-1	1	-1	2	3
4	Willow Slough Bypass	3	2	5	1	3	2
6	Putah Creek	1	-1	1	1	1	1
11	Tule Canal @ 80	1	1	2	1	1	1
12	Toe Drain	1	-1	1	-1	1	1

DISSOLVED SELENIUM (ug/l)

Site #	ampling Si	Results					
		NOV	JAN	APR	JUN	AUG	SEPT
2	Ridge Cut	1	-2	2	6	4	-2
3	Cache Cre	1	-2	1	1	1	-2
4	Willow Slo	2	2	4	3	3	-2
6	Putah Cree	1	-2	1	1	1	-2
11	Tule Canal	1	-2	1	2	1	-2
12	Toe Drain	-1	-2	1	1	1	-2

Total Mercury (ng/l)

Site #	Sampling Site	Results											
		NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JLY	AUG	SEP	OCT
1	Fremont Weir				25								
2	Ridge Cut	4	3	5	10	6	6	15	27	12	10	4	6
3	Cache Creek	15	13	12	34	11	6	23	25	13	16	7	13
4	Willow Slough Bypass	9	3	4	11	7	8	15	11	12	16	18	10
5	YB Wildlife Area	8	11	12			10	30	43	18	22	14	8
6	Putah Creek	1	3	3	17	3	6	10	8	3	6	2	3
7	Z Drain	6	7	5	6	6	4	10	15	11	12	12	10
8	Sacramento Weir				18								
9	Woodland R1	5	5	7	37	6	9	12	11	9	9	15	6
10	Woodland R2	9	5	9	30	10	10	12	10	8	9	13	7
11	Tule Canal @ 80	8	8	12	41	12	10	19	17	10	10	9	8
12	Toe Drain	9		19		8	13	27	25	19	16	15	14

Methylmercury (ng/l)

Site #	Sampling Site	Results					
		NOV	JAN	APR	JUN	AUG	SEPT
2	Ridge Cut	0.3	0.3	0.2	0.3	0.6	0.2
3	Cache Creek	0.3	1.1	0.3	0.6	0.5	0.3
4	Willow Slough Bypass	0.4	0.2	0.3	0.3	0.4	0.3
6	Putah Creek	0.1	0.1	0.1	0.3	0.2	0.1
11	Tule Canal @ 80	0.3	0.5	0.3	0.4	0.4	0.2
12	Toe Drain	0.1	0.9	0.3	0.3	0.1	0.2

Streambed Sediment Samples

Effects of Yolo Bypass sediment samples on *Hyalella azteca* survival and growth.		
Sample ID	**Mean % Survival**	**Mean Weight (mg, dry wt)**
Control	97.5	0.15
Ridge Cut	87.5*	0.13*
Tule Canal	96.2	0.14
Putah Creek	97.5	0.14
Willow Slough	93.8	0.14
Cache Creek	96.2	0.18
Toe Drain	97.5	0.14

* Significantly less than the Control treatment response at p<0.05

Effects of Yolo Bypass sediment samples on *Chironomus tentans* survival and growth.		
Sample ID	**Mean % Survival**	**Mean Weight (mg, dry wt)**
Control	92.5	0.82
Ridge Cut	67.5*	0.8
Tule Canal	81.2*	0.83
Putah Creek	76.2*	1.13
Willow Slough	96.2	0.65*
Cache Creek	83.8	0.97
Toe Drain	77.5*	0.88

* Significantly less than the Control treatment response at p<0.05

Total Mercury (ng/g)

Site #	Sampling Site	Wet Weight
		SEPT
2	Ridge Cut	72
3	Cache Creek	220
4	Willow Slough Bypass	104
5	YB Wildlife Area	50
6	Putah Creek	628
7	Z Drain	17
9	Woodland R1	65
10	Woodland R2	46
11	Tule Canal @ 80	53
12	Toe Drain	80

Methylmercury (ng/g)

Site #	Sampling Site	Wet Weight
		SEPT
2	Ridge Cut	0.33
3	Cache Creek	0.67
4	Willow Slough Bypass	0.28
5	YB Wildlife Area	1.31
6	Putah Creek	0.31
7	Z Drain	0.19
9	Woodland R1	0.53
10	Woodland R2	0.38
11	Tule Canal @ 80	0.13
12	Toe Drain	0.11

Aluminum (mg/kg)	
RIDGE CUT	1500
CACHE CREEK	7100
TULE CANAL	13000
TOE DRAIN	9200
PUTAH CREEK	7700
WILLOW SLOUGH	13000

Boron (mg/kg)
Not Detected

Chromium (mg/kg)	
RIDGE CUT	57
CACHE CREEK	54
TULE CANAL	52
TOE DRAIN	69
PUTAH CREEK	79
WILLOW SLOUGH	62

Copper (mg/kg)	
RIDGE CUT	39
CACHE CREEK	21
TULE CANAL	32
TOE DRAIN	22
PUTAH CREEK	20
WILLOW SLOUGH	32

Lead (mg/kg)	
RIDGE CUT	10
CACHE CREEK	4
TULE CANAL	11
TOE DRAIN	6
PUTAH CREEK	6
WILLOW SLOUGH	9

Selenium (mg/kg)	
RIDGE CUT	2
CACHE CREEK	ND
TULE CANAL	ND
TOE DRAIN	ND
PUTAH CREEK	ND
WILLOW SLOUGH	ND

Toxicity Test Results for Water Column Samples

Acute (96-hr) Toxicity Tests

Ceriodaphnia (% Survival)						
Site #	**Sampling Site**	**JUNE**	**JULY**	**AUG**	**SEPT**	**OCT**
	Lab Control	100	100	100	100	100
7	Z Drain	100	100	100	100	100
11	Tule Canal @ 80	95	100	100	100	100
12	Toe Drain	100	100	100	100	100

Algae (Cell Growth)						
Site #	**Sampling Site**	**JUNE**	**JULY**	**AUG**	**SEPT**	**OCT**
	Lab Control	100	100	-	-	-
7	Z Drain	100	100	<100	100	100
11	Tule Canal @ 80	100	100	<100	100	100
12	Toe Drain	100	100	<100	100	100

Fathead Minnow (% Survival)						
Site #	**Sampling Site**	**JUNE**	**JULY**	**AUG**	**SEPT**	**OCT**
	Lab Control	100	100	100	95	100
7	Z Drain	98	98	100	78	95
11	Tule Canal @ 80	100	98	100	93	100
12	Toe Drain	98	98	100	65	100

Chronic (7-day) Toxicity Tests

Ceriodaphnia (% Survival)					
Site #	**Sampling Site**	**JAN**	**APRIL**	**AUG**	**SEPT**
	Ceriodaphnia (% Survival)				
	Lab Control	90	100	100	100
2	Ridge Cut	100	100	100	100
3	Cache Creek	100	80	100	100
4	Willow Slough Bypass	100	100	100	100
11	Tule Canal @ 80	100	90	100	100

Algae (Cell Growth)

Site #	Sampling Site	JAN	APRIL	AUG	SEPT
	Algae (Cell Growth)				
	Lab Control	100	100	-	-
2	Ridge Cut	100	100	<100	100
3	Cache Creek	100	100	<100	<100
4	Willow Slough Bypass	100	100	<100	100
11	Tule Canal @ 80	100	100	<100	100

Fathead Minnow (% Survival)

Site #	Sampling Site	APRIL	AUG	SEPT
	Fathead Minnow (% Survival)			
	Lab Control	100	100	92.5
2	Ridge Cut	72.5	100	83
3	Cache Creek	100	100	93
4	Willow Slough Bypass	77.5	100	80
11	Tule Canal @ 80	97.5	100	85

Toxicity Test Results for Streambed Sediment Samples

Effects of Yolo Bypass sediment samples on *Hyalella azteca* survival and growth.

Sample ID	Mean % Survival	Mean Weight (mg, dry wt)
Control	97.5	0.15
Ridge Cut	87.5*	0.13*
Tule Canal	96.2	0.14
Putah Creek	97.5	0.14
Willow Slough	93.8	0.14
Cache Creek	96.2	0.18
Toe Drain	97.5	0.14

* Significantly less than the Control treatment response at $p<0.05$

Effects of Yolo Bypass sediment samples on *Chironomus tentans* survival and growth.

Sample ID	Mean % Survival	Mean Weight (mg, dry wt)
Control	92.5	0.82
Ridge Cut	67.5*	0.8
Tule Canal	81.2*	0.83
Putah Creek	76.2*	1.13
Willow Slough	96.2	0.65*
Cache Creek	83.8	0.97
Toe Drain	77.5*	0.88

* Significantly less than the Control treatment response at $p<0.05$

Appendix 6-B. Summary Statistics for Samples Collected During the Study Period

Water Column Samples

TOTAL COLIFORM (MPN/100ml)

Site #	Site Name	n	n det	Min	Max	Average	Median	MDL	Exceedances
1	Fremont Weir	1	1	5,000	5,000	5,000	5,000	2	na
2	Ridge Cut	12	12	21	160,000	23,122	16,000	2	na
3	Cache Creek	12	12	1,200	50,000	13,742	7,750	2	na
4	Willow Slough Bypass	12	12	9,000	160,000	45,583	30,000	2	na
5	YB Wildlife Area	9	9	1,100	50,000	11,289	3,000	2	na
6	Putah Creek	12	12	40	24,000	6,702	3,000	2	na
7	Z Drain	12	12	1,700	220,000	66,700	26,500	2	na
8	Sacramento Weir	1	1	11,000	11,000	11,000	11,000	2	na
9	Woodland R1	12	12	1,400	160,000	34,500	5,000	2	na
10	Woodland R2	12	12	1,100	90,000	22,025	13,000	2	na
11	Tule Canal @ 80	12	12	2,200	170,000	31,192	16,500	2	na
12	Toe Drain	10	10	1,700	160,000	25,670	12,000	2	na

na. Objective not available

FECAL COLIFORM (MPN/100ml)

Site #	Site Name	n	n det	Min	Max	Average	Median	MDL	Exceedances (a)
1	Fremont Weir	1	1	3,000	3,000	3,000	3,000	2	1
2	Ridge Cut	12	10	2	2,800	552	50	2	3
3	Cache Creek	12	12	20	5,000	760	50	2	3
4	Willow Slough Bypass	12	12	40	50,000	8,692	3,000	2	10
5	YB Wildlife Area	9	9	20	2,200	282	40	2	1
6	Putah Creek	12	12	17	1,100	232	40	2	2
7	Z Drain	12	12	20	30,000	6,600	5,000	2	7
8	Sacramento Weir	1	1	9,000	9,000	9,000	9,000	2	1
9	Woodland R1	12	12	20	16,000	2,668	675	2	6
10	Woodland R2	12	12	20	17,000	2,298	1,050	2	7
11	Tule Canal @ 80	12	12	17	9,000	2,006	80	2	5
12	Toe Drain	10	9	20	17,000	2,590	50	2	3

a. California Basin Plan, Region 5 Bacteria Criteria, Rec-1, 30-Day Period = 200 MPN/100ml as 30-Day Average

E. COLI (MPN/100ml)

Site #	Site Name	n	n det	Min	Max	Average	Median	MDL	Exceedances (a)
1	Fremont Weir	1	1	3,000	3,000	3,000	3,000	2	1
2	Ridge Cut	12	10	2	3,000	614	40	2	3
3	Cache Creek	12	12	17	5,000	939	45	2	4
4	Willow Slough Bypass	12	12	40	50,000	6,926	1,700	2	10
5	YB Wildlife Area	9	9	17	80	40	40	2	0
6	Putah Creek	12	12	8	1,700	259	30	2	2
7	Z Drain	12	12	20	30,000	5,456	3,700	2	8
8	Sacramento Weir	1	1	5,000	5,000	5,000	5,000	2	1
9	Woodland R1	12	12	20	16,000	2,022	45	2	4
10	Woodland R2	12	12	17	17,000	1,817	75	2	4
11	Tule Canal @ 80	12	12	11	3,000	631	80	2	4
12	Toe Drain	10	9	20	17,000	2,055	45	2	3

a. Proposed Basin Plan criteria for REC-1 = 126 MPN/100ml as geometric mean of at least 5 samples in a 30-day period.

ALUMINUM (ug/L)

Site #	Site Name	n	n det	Min	Max	Average	Median	MDL	Exceedances (a)
	TOTAL								
2	Ridge Cut	6	6	700	3,300	1,833	1,800	0.7	6
3	Cache Creek	6	6	500	2,800	1,300	1,000	0.7	6
4	Willow Slough Bypass	6	6	800	4,100	2,083	1,800	0.7	6
6	Putah Creek	6	6	70	1,800	467	185	0.7	5
11	Tule Canal @ 80	6	6	1,300	3,000	2,067	1,800	0.7	6
12	Toe Drain	6	6	1,600	6,000	3,083	2,700	0.7	6
	DISSOLVED								
2	Ridge Cut	6	2	20	20	20	20	0.6	na
3	Cache Creek	6	2	10	20	15	15	0.6	na
4	Willow Slough Bypass	6	1	10	10	10	10	0.6	na
6	Putah Creek	6	1	10	10	10	10	0.6	na
11	Tule Canal @ 80	6	2	10	10	10	10	0.6	na
12	Toe Drain	6	4	20	20	20	20	0.6	na

a. US EPA Ambient Water Quality Report 2002 = 87 ug/l
na. Objective not available

BORON (ug/L)

Site #	Site Name	n	n det	Min	Max	Average	Median	MDL	Exceedances (a)
	TOTAL								
2	Ridge Cut	6	6	200	2,700	1,243	955	0.02	4
3	Cache Creek	6	6	550	2,300	1,475	1,550	0.02	5
4	Willow Slough Bypass	6	6	1,300	1,700	1,450	1,400	0.02	6
6	Putah Creek	6	6	350	1,400	648	455	0.02	2
11	Tule Canal @ 80	6	6	550	1,700	1,042	1,050	0.02	5
12	Toe Drain	6	6	140	1,700	827	625	0.02	3
	DISSOLVED								
2	Ridge Cut	6	6	200	2,700	1,273	1,140	0.02	na
3	Cache Creek	6	6	490	2,400	1,448	1,450	0.02	na
4	Willow Slough Bypass	6	6	1,300	1,500	1,367	1,350	0.02	na
6	Putah Creek	6	6	340	500	403	395	0.02	na
11	Tule Canal @ 80	6	6	530	1,500	972	1,000	0.02	na
12	Toe Drain	6	6	130	1,700	663	605	0.02	na

a. UN Agriculture Goals = 700 ug/l
na. Objective not available

CHROMIUM (ug/L)

Site #	Site Name	n	n det	Min	Max	Average	Median	MDL	Exceedances
	TOTAL								**(a)**
2	Ridge Cut	6	6	9	13	11	11	0.02	1
3	Cache Creek	6	6	4	6	5	5	0.02	0
4	Willow Slough Bypass	6	6	4	15	9	8	0.02	1
6	Putah Creek	6	6	8	19	13	12	0.02	2
11	Tule Canal @ 80	6	6	7	10	9	10	0.02	0
12	Toe Drain	6	6	7	14	10	10	0.02	1
	DISSOLVED								**(b)**
2	Ridge Cut	6	6	0.4	0.4	0.4	0.4	0.02	0
3	Cache Creek	6	6	1.2	1.2	1.2	1.2	0.02	0
4	Willow Slough Bypass	6	6	1.6	1.6	1.6	1.6	0.02	0
6	Putah Creek	6	6	4	4	4	4	0.02	0
11	Tule Canal @ 80	6	6	0.49	0.49	0.49	0.49	0.02	0
12	Toe Drain	6	6	0.8	0.8	0.8	0.8	0.02	0

a. California Toxics Rule, total Chromium VI, chronic freshwater organism = 11.43 ug/l
a. California Toxics Rule, dissolved Chromium VI, chronic freshwater organism = 11 ug/l

COPPER (ug/L)

Site #	Site Name	n	n det	Min	Max	Average	Median	MDL	Exceedances
	TOTAL								**(a)**
2	Ridge Cut	6	6	3	9	6	7	0.03	0
3	Cache Creek	6	6	3	8	5	5	0.03	0
4	Willow Slough Bypass	6	6	5	11	7	7	0.03	0
6	Putah Creek	6	6	2	5	3	2	0.03	0
11	Tule Canal @ 80	6	6	6	9	7	7	0.03	0
12	Toe Drain	6	6	5	12	8	8	0.03	0
	DISSOLVED								**(b)**
2	Ridge Cut	6	6	2.4	2.4	2.4	2.4	0.02	0
3	Cache Creek	6	6	1.4	1.4	1.4	1.4	0.02	0
4	Willow Slough Bypass	6	6	3.4	3.4	3.4	3.4	0.02	0
6	Putah Creek	6	6	1.9	1.9	1.9	1.9	0.02	0
11	Tule Canal @ 80	6	6	3.1	3.1	3.1	3.1	0.02	0
12	Toe Drain	6	6	2.4	2.4	2.4	2.4	0.02	0

a.California Toxics Rule, chronic freshwater organism, total calculated with average hardness of Tule Canal and Toe Drain of 220 mg/l = 18.3 ug/l

b.California Toxics Rule, chronic freshwater organism, dissolved calculated with average hardness of Tule Canal and Toe Drain of 220 mg/l = 17.6 ug/l

LEAD (ug/L)

Site #	Site Name	n	n det	Min	Max	Average	Median	MDL	Exceedances
	TOTAL								**(a)**
2	Ridge Cut	6	6	0.4	1.7	1.2	1.3	0.04	0
3	Cache Creek	6	6	0.4	1.5	0.8	0.6	0.04	0
4	Willow Slough Bypass	6	6	1.1	2.3	1.6	1.5	0.04	0
6	Putah Creek	6	6	0.1	1.1	0.4	0.2	0.04	0
11	Tule Canal @ 80	6	6	0.7	1.4	1.1	1.2	0.04	0
12	Toe Drain	6	6	1.1	2.2	1.5	1.3	0.04	0
	DISSOLVED								**(b)**
2	Ridge Cut	6	1	0.3	0.3	0.3	0.3	0.04	0
3	Cache Creek	6	1	0.3	0.3	0.3	0.3	0.04	0
4	Willow Slough Bypass	6	1	0.3	0.3	0.3	0.3	0.04	0
6	Putah Creek	6	1	0.3	0.3	0.3	0.3	0.04	0
11	Tule Canal @ 80	6	1	0.3	0.3	0.3	0.3	0.04	0
12	Toe Drain	6	1	0.3	0.3	0.3	0.3	0.04	0

a.California Toxics Rule, chronic freshwater organism, total calculated with average hardness of Tule Canal and Toe Drain of 220 mg/l = 8.68 ug/l

b.California Toxics Rule, chronic freshwater organism, dissolved calculated with average hardness of Tule Canal and Toe Drain of 220 mg/l = 5.9 ug/l

MERCURY (ng/L)

Site #	Site Name	n	n det	Min	Max	Average	Median	MDL	Exceedances
	TOTAL MERCURY								(a)
1	Fremont Weir	1	1	25.00	25.00	25.00	25.00	0.15	0
2	Ridge Cut	12	12	3.06	27.10	8.99	5.89	0.15	0
3	Cache Creek	12	12	6.29	33.80	15.67	12.95	0.15	0
4	Willow Slough Bypass	12	12	2.71	17.80	10.31	10.28	0.15	0
5	YB Wildlife Area	10	10	7.98	43.00	17.66	13.20	0.15	0
6	Putah Creek	12	12	1.39	16.70	5.42	3.35	0.15	0
7	Z Drain	12	12	4.05	14.90	8.58	8.32	0.15	0
8	Sacramento Weir	1	1	18.10	18.10	18.10	18.10	0.15	0
9	Woodland R1	12	12	4.99	37.30	10.86	8.60	0.15	0
10	Woodland R2	2	12	5.25	30.10	10.91	9.16	0.15	0
11	Tule Canal @ 80	12	12	8.08	40.90	13.73	10.23	0.15	0
12	Toe Drain	10	10	8.12	26.80	16.47	15.25	0.15	0
	METHYLMERCURY								(b)
2	Ridge Cut	6	6	0.15	0.58	0.30	0.28	0.025	6
3	Cache Creek	6	6	0.25	1.06	0.48	0.38	0.025	6
4	Willow Slough Bypass	6	6	0.24	0.44	0.32	0.29	0.025	6
6	Putah Creek	6	6	0.07	0.32	0.15	0.13	0.025	6
11	Tule Canal @ 80	6	6	0.21	0.51	0.35	0.34	0.025	6
12	Toe Drain	6	6	0.13	0.90	0.32	0.24	0.025	6

a. California Toxics Rule for Total Mercury = 51 ng/l

b. Proposed Cache Creek Mercury TMDL for Methylmercury = 0.06 ng/l

SELENIUM (ug/L)

Site #	Site Name	n	n det	Min	Max	Average	Median	MDL	Exceedances
TOTAL									**(a)**
2	Ridge Cut	6	5	1	5	3	2	0.05	2
3	Cache Creek	6	4	1	3	2	2	0.05	0
4	Willow Slough Bypass	6	6	1	5	3	3	0.05	1
6	Putah Creek	6	5	1	1	1	1	0.05	0
11	Tule Canal @ 80	6	6	1	2	1	1	0.05	0
12	Toe Drain	6	4	1	1	1	1	0.05	0
DISSOLVED									**(b)**
2	Ridge Cut	6	4	1	6	3	3	0.05	1
3	Cache Creek	6	4	1	1	1	1	0.05	0
4	Willow Slough Bypass	6	4	2	4	3	3	0.05	0
6	Putah Creek	6	4	1	1	1	1	0.05	0
11	Tule Canal @ 80	6	4	1	2	1	1	0.05	0
12	Toe Drain	6	4	1	1	1	1	0.05	0

a. California Toxics Rule, total, chronic freshwater organism = 5 ug/l
b. California Toxics Rule, dissolved, chronic freshwater organism = 5 ug/l

NITRATE as N (mg/L)

Site #	Site Name	n	n det	Min	Max	Average	Median	MDL	Exceedances (a)
2	Ridge Cut	6	4	0.4	1.7	0.8	0.4	0.03	0
3	Cache Creek	6	4	0.1	1.7	1.1	1.4	0.03	0
4	Willow Slough Bypass	6	6	0.1	1.0	0.5	0.5	0.03	0
6	Putah Creek	6	6	0.7	1.7	1.1	1.0	0.03	0
11	Tule Canal @ 80	6	6	0.8	1.3	1.0	0.9	0.03	0
12	Toe Drain	6	4	0.2	2.9	1.2	0.5	0.03	0

a. US EPA Ambient WQ = 10 mg/l

ORGANIC CARBON (mg/L)

Site #	Site Name	n	n det	Min	Max	Average	Median	MDL	Exceedances
TOTAL									
2	Ridge Cut	6	6	4	10	6	5	0.09	na
3	Cache Creek	6	6	3	8	4	4	0.09	na
4	Willow Slough Bypass	6	6	8	15	10	10	0.09	na
6	Putah Creek	6	6	2	10	5	5	0.09	na
7	Z Drain	5	5	8	10	9	9	0.09	na
11	Tule Canal @ 80	8	8	4	13	8	9	0.09	na
12	Toe Drain	8	8	3	11	7	8	0.09	na
DISSOLVED									
2	Ridge Cut	6	6	4	9	7	8	0.09	na
3	Cache Creek	6	5	4	10	6	6	0.09	na
4	Willow Slough Bypass	6	6	7	13	9	8	0.09	na
6	Putah Creek	6	5	4	6	5	5	0.09	na
7	Z Drain	5	5	4	10	7	7	0.09	na
11	Tule Canal @ 80	8	8	6	19	9	7	0.09	na
12	Toe Drain	8	8	4	10	7	8	0.09	na

na. Objective not available

PESTICIDES (ug/L)

Site #	Site	n	n det	Min	Max	Average	Median	MDL	Exceedances
	CARBAMATE	36	9						
	Diuron								(a)
2	Ridge Cut	6	2	0.2 (f)	0.3 (f)	0.3	0.3	0.4	0
4	Willow Slough Bypass	6	3	0.2 (f)	0.8	0.47	0.4	0.4	0
11	Tule Canal @ 80	6	2	0.1 (f)	0.3 (f)	0.2	0.2	0.4	0
12	Toe Drain	6	1	0.5	0.5	0.5	0.5	0.4	0
	Methomyl								
3	Cache Creek	6	1	0.07	0.07	0.07	0.07	0.07	0
	CHLORINATED	36	3						(c)
	4,4'-DDE								
2	Ridge Cut	6	2	0.01	0.02	0.015	0.015	0.001	2
4	Willow Slough Bypass	6	1	0.01	0.01	0.01	0.01	0.001	1
	ORGANOPHOSPHATE	40	6						
	Chlorpyrifos								(d)
2	Ridge Cut	7	2	0.011	0.043	0.027	0.027	0.005	1
4	Willow Slough Bypass	7	1	0.01	0.01	0.01	0.01	0.005	0
6	Putah Creek	6	1	0.017	0.017	0.017	0.017	0.005	1
	Diazinon								(e)
2	Ridge Cut	7	1	0.032	0.032	0.032	0.032	0.005	0
3	Cache Creek	7	1	0.035	0.035	0.035	0.035	0.005	0

a. Diuron criterion = 10 ug/L, USEPA lifetime health advisory
b. Methomyl criterion = 0.52 ug/L, USEPA National Recommended Ambient Water Quality Criterion
c. 4'4' DDE criterion = 0.0005 ug/L, CTR Human Health Criterion
d. Chlorpyrifos criterion = 0.014 ug/L, CA DFG Hazard Assessment criterion
e. Diazinon criterion = 0.1 ug/L, draft USEPA National Recommended Ambient Water Quality Criterion
f. Value reported below the analytical detection limit.

TOTAL SOLIDS (mg/L)

Site #	Site Name	n	n det	Min	Max	Average	Median	MDL	Exceedances
	DISSOLVED								(a)
2	Ridge Cut	6	6	340	680	500	480	0.05	3
3	Cache Creek	6	6	200	520	358	355	0.05	1
4	Willow Slough Bypass	6	6	440	880	653	680	0.05	5
6	Putah Creek	6	6	250	360	298	300	0.05	0
7	Z Drain	5	5	200	340	266	270	0.05	0
11	Tule Canal @ 80	8	8	290	570	455	470	0.05	4
12	Toe Drain	8	8	130	580	296	260	0.05	1
	SUSPENDED								
2	Ridge Cut	6	6	46	88	68	73	na	na
3	Cache Creek	6	6	16	62	35	33	na	na
4	Willow Slough Bypass	6	6	32	110	60	56	na	na
6	Putah Creek	6	5	3	14	9	9	na	na
7	Z Drain	5	5	66	110	90	94	na	na
11	Tule Canal @ 80	8	8	32	80	54	48	na	na
12	Toe Drain	8	8	36	96	60	58	na	na

a. UN Agriculture Goals = 450 mg/l
na. MDL or Objective not available

EC (umhos/cm)

Site #	Site Name	n	n det	Min	Max	Average	Median	MDL	Exceedances(a)
1	Fremont Weir	1	1	158	158	158	158	na	0
2	Ridge Cut	12	12	319	1,109	749	779	na	7
3	Cache Creek	12	12	280	802	562	570	na	2
4	Willow Slough Bypass	12	12	608	1,596	1,001	921	na	10
5	YB Wildlife Area	10	10	361	920	664	640	na	4
6	Putah Creek	12	12	359	853	524	509	na	1
7	Z Drain	12	12	411	1,087	666	603	na	5
8	Sacramento Weir	1	1	81	81	81	81	na	0
9	Woodland R1	12	12	80	916	560	555	na	1
10	Woodland R2	12	12	158	896	671	705	na	6
11	Tule Canal @ 80	12	12	210	895	688	727	na	7
12	Toe Drain	10	10	193	1,013	467	395	na	2

a. UN Agriculture Goals = 700 uS/cm

HARDNESS (mg/L)

Site #	Site Name	n	n det	Min	Max	Average(a	Median	MDL	Exceedances
2	Ridge Cut	6	6	180	660	328	275	1.3	na
3	Cache Creek	6	6	140	340	252	250	1.3	na
4	Willow Slough Bypass	6	6	260	400	347	360	1.3	na
6	Putah Creek	6	6	220	280	247	245	1.3	na
11	Tule Canal @ 80	6	6	190	290	238	235	1.3	na
12	Toe Drain	6	6	100	310	208	220	1.3	na

a. Used to calculate CTR objectives for total copper and lead
na. Objective not available

COLOR (cu)

Site #	Site Name	n	n det	Min	Max	Average	Median	MDL	Exceedances
2	Ridge Cut	6	6	70	200	122	113	na	na
3	Cache Creek	6	6	28	250	91	55	na	na
4	Willow Slough Bypass	6	6	17	200	90	75	na	na
6	Putah Creek	6	6	12	400	91	20	na	na
7	Z Drain	5	5	140	400	209	175	na	na
11	Tule Canal @ 80	8	8	60	200	101	78	na	na
12	Toe Drain	8	8	50	400	148	130	na	na

na. Objective not available

Toxicity Test Results for Water Column Samples

7 Day Chronic Toxicity

Site #	Site Name	n	n det	Min	Max	Average	Median	MDL	Exceedances
Ceriodaphnia (% Survival)									
	Lab Control	4	4	90	100	98	100	na	
2	Ridge Cut	4	4	100	100	100	100	na	0
3	Cache Creek	4	4	80	100	95	100	na	0
4	Willow Slough Bypass	4	4	100	100	100	100	na	0
11	Tule Canal @ 80	4	4	90	100	98	100	na	0
Algae (Cell Growth)									
	Lab Control	4	4	100	100	100	100	na	
2	Ridge Cut	4	4	100	100	100	100	na	0
3	Cache Creek	4	4	100	100	100	100	na	0
4	Willow Slough Bypass	4	4	100	100	100	100	na	0
11	Tule Canal @ 80	4	4	100	100	100	100	na	0
Fathead Minnow (% Survival)									
	Lab Control	3	3	93	100	98	100	na	
2	Ridge Cut	3	3	73	100	85	83	na	1
3	Cache Creek	3	3	93	100	98	100	na	0
4	Willow Slough Bypass	3	3	78	100	86	80	na	0
11	Tule Canal @ 80	3	3	85	100	94	98	na	0

Exceedance = significant toxicity

96 Hour Acute Toxicity

Site #	Site Name	n	n det	Min	Max	Average	Median	MDL	Exceedances
Ceriodaphnia (% Survival)									
	Lab Control	5	5	100	100	100	100	na	
7	Z Drain	5	5	100	100	100	100	na	0
11	Tule Canal @ 80	5	5	100	100	100	100	na	0
12	Toe Drain	5	5	100	100	100	100	na	0
Algae (Cell Growth)									
	Lab Control	5	5	100	100	100	100	na	
7	Z Drain	5	5	<100	100	100	100	na	0
11	Tule Canal @ 80	5	5	<100	100	100	100	na	0
12	Toe Drain	5	5	<100	100	100	100	na	0
Fathead Minnow (% Survival)									
	Lab Control	5	5	95	100	99	100	na	
7	Z Drain	5	5	78	100	93	96	na	1
11	Tule Canal @ 80	5	5	93	100	98	99	na	0
12	Toe Drain	5	5	65	100	91	99	na	1

Exceedance = significant toxicity

Appendix 7. LWA Tech Memo of Potential Control Measures for POCs

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MEMORANDUM

Control Measures for Pollutants of Concern in the Yolo Bypass

Prepared for:

Yolo Bypass Water Quality Management Plan Stakeholder Advisory Group

March 9, 2005

Introduction

This technical memorandum presents a compilation and assessment of potential control measures to reduce pollutants of concern (POCs) in the Yolo Bypass.

POCs Addressed

The POCs addressed in this memorandum are briefly described below. The priorities for which the POCs have been categorized are based on the monitoring results from a year-long monitoring program that was conducted throughout the Yolo Bypass.

High Priority:

- **Mercury.** Mercury is a concern throughout the region because of bioaccumulation through the aquatic food chain and potential health risks to fish-eating wildlife and humans. Mercury was mined extensively in the Cache and Putah Creek watersheds prior to any environmental regulations. Mercury from these and natural sources such as erosion of native soils and discharges from mineral springs continue to contaminate local waterways. Methylmercury is the form of most concern from the standpoint of bio-uptake. Wetlands tend to enhance the methylation process that drives bioaccumulation of mercury in the food web.
- **Salinity.** High salts content in water potentially impacts productivity of agricultural crops and may create problems for municipal uses. Local groundwater aquifers, the principal water supply source for the Cities of Davis and Woodland, are relatively high in salts content. Urban water uses, particularly the use of water softeners, increase salts content in wastewater discharges even more. Irrigation practices that enhance evaporation and leaching also increase salt content of irrigation return flows.

Medium Priority:

- **Aluminum.** There are two primary forms of aluminum that may be found in water, aluminum silicate and aluminum hydroxide. Aluminum silicate is naturally aluminum that is bound to sediment particles and is not considered to be toxic. The aluminum hydroxide form of aluminum can be toxic to aquatic organisms. Aluminum is a major component of the Earth's crust, and is commonly present in groundwater and runoff due to natural sources (soil and parent geological materials).
- **Bacteria.** Total coliform, fecal coliform and E. coli are used by regulatory agencies as indicators of human pathogens. The presence of these constituents may also indicate contamination from domestic animals and wildlife. The presence of high levels of coliform and E. coli may indicate the presence of pathogens of human health concerns in waters used for contact recreation. The presence of high levels of coliform and E. coli in irrigation water may also indicate the presences of pathogens that cause human health concerns in some food crops.
- **Boron.** Boron is an element commonly found in saline groundwater sources. It has properties that are somewhat like metals. The major source locally is leaching from soil and extraction in groundwater. High concentrations of boron can stress rice and other irrigated crops.
- **Organic Carbon.** Organic carbon in water increases productivity of aquatic ecosystems but is detrimental to drinking water supplies. The presence of high levels of organic carbon in drinking water requires drinking water providers to increase the chlorination process in order for drinking water to meet appropriate standards when delivered to

consumers. However, the chlorination process creates harmful disinfection by-products known as trihalomethanes. Trihalomethanes are considered to be carcinogenic.

- **Pesticides.** Carbamate, organochlorine, and organophosphate based pesticides have been detected in Bypass water by existing water monitoring programs. The presence of these pesticides above threshold concentrations can cause negative impacts on aquatic life within the Bypass. Common sources of such pesticides, such as agricultural and urban runoff, exist in the watershed.

Seasonality Issues

The water quality of the Bypass and control measures to improve it can be divided into three broad “seasons”:

- Dry (Irrigation) Season: Major sources of water include effluent from the municipal wastewater treatment plants (POTWs) of the Cities of Woodland and Davis and the UC Davis campus, imported Sacramento River water (for irrigation purposes), and water from the Toe Drain that is pumped onto agricultural fields for irrigation and to wildlife habitat. Low flows from Putah Creek, Willow Slough, Cache Creek, and Knight’s Landing Ridge Cut also contribute. Agricultural tailwater is largely recycled
- Wet Season: Pulses of urban stormwater runoff combine with POTW effluent and higher flows in creeks to provide the primary sources of water within the Bypass. The available water created during the wet season is often used to flood public and private lands for duck clubs, wildlife habitat and the break-down of rice stubble remaining on rice fields after harvest.
- Flooded: Flood flows in the Bypass come from the Feather River and upper Sacramento River watersheds via the Fremont Weir at the northern end of the Bypass, from the American River via the Sacramento Weir along the east side of the Bypass, and from local creeks. These flood flows drastically alter what would be considered “average” conditions. It is not uncommon for flood flows to exceed 150,000 cfs in the Bypass during wet years, as compared to 20,000 cfs in Cache Creek, and 20 cfs combined POTW effluent.

Options for Addressing the POCs

Potential options for addressing the high and medium priority POCs fall into three main categories:

- Implement control measures;
- Continue monitoring and undertake special studies; and
- Develop a site-specific objective and change the designated beneficial uses through a Use Attainability Analysis.

The focus of this memorandum is to identify and quantify to the extent practicable potential control measures to implement. Control measures are defined as structures, activities, management practices, or processes that may minimize pollutant loads to the Yolo Bypass. Best Management Practices (BMPs) are control measure activities recognized to minimize pollutant loads in the most effective, efficient manner. However, the term “Best” is not meant to imply that such practices are the only effective and efficient way to minimize pollutant loads. The term “control measure” is used to represent any activity or structural device used to control the discharge of POCs to the Bypass. In general, BMPs traditionally apply to agricultural non-point sources of pollution and urban stormwater while control measures are often associated with point sources of pollution such as POTW effluent.

Control measures that could potentially be used to address at least one of the POCs are listed in Table 1. They are generally in order of upstream/source control to downstream/discharge control. Each control measure listed in this table is described in its own section, following a standard format:

- POCs addressed;
- Description;
- Benefits;
- Costs; and
- Other considerations.

Costs and benefits are quantified to the extent practicable and generally in terms of order-of-magnitude estimates. Information on past, present, and future planned implementation of these control measures is also provided, where known.

Table 1. Summary table of control measures described in this memorandum.

BMP or Control Measure		POCs Addressed						
#	Name	Aluminum	Bacteria	Boron	Mercury	Org. C	Pesti-cides	Salinity
1	**Conduct Outreach and Education**		X		X	X	X	X
2	**Reduce Local Groundwater Use**							
2a	Develop Alternative Water Supplies			X			?	X
2b	Reduce Urban Water Demand			X				X
3	**Reduce POTW Influent Loads**							
3a	Encourage Alternatives to Conventional Water Softeners							X
3b	Outreach on Proper Operation of Water Softeners							X
3c	Conduct Mercury-specific Outreach and Education				X			
3d	Enhance Industrial Pretreatment	X			X			X
4	**Enhance POTW Treatment**							
4a	Install Tertiary Treatment	X	X		X	X	X	
4b	Install Microfiltration – Reverse Osmosis Filters			X				X
5	**Improve Urban Storm Water Management**							
5a	Minimize Effects of New Development		X			X	X	
5b	Outreach to Minimize Stormwater Impacts	X	X	X	X	X	X	X
6	**Improve Rural Land and Water Management**							
6a	Construct or Improve Settling Basins	X			X		X	
6b	Enhance IPM Programs						X	
6c	Enhance Irrigation Water Management						X	X
6d	Optimize Pesticide Applications						X	
6e	Restrict or Change Pesticide Use						X	
6f	Minimize Erosion and Sediment Transport to Waterways	X	X		X	X	X	
6g	Remove or Stabilize Mine Waste				X			
7	**Manage Water Resources for Water Quality Benefits**							
7a	Minimize POTW Discharges to the Bypass							X
7b	Manage Water Use in Bypass Wetlands	X	?	?	?	X	X	?
7b	Alter Inter-basin Water Transfers				?	?	?	X

"X" indicates some benefits *likely* could be realized by applying this control measure in the watershed.
"?" indicates some potential *benefits or detriments* could be realized by applying this control measure in the watershed.

1 Conduct General Outreach and Education

POCs addressed: bacteria, mercury, organic carbon, pesticides, salinity

Description

General outreach efforts that could be considered include: 1) post information on web sites maintained by municipalities and environmental organizations; 2) develop fact sheets for dissemination to the public; 3) utilize press releases at appropriate times (e.g., Earth Day); 4) prepare and give PowerPoint presentations at appropriate venues; and 5) enhance communication and collaboration among agencies and other authorities that manage water resources affecting the Bypass. These activities improve the public's general awareness of local water quality issues impacted by their actions. Pollutant-specific outreach is addressed separately in this memo and would overlap considerably with this control measure.

An additional outreach activity is to inform farm workers and recreational visitors in the Bypass that bacteria levels are high to discourage swimming.

Another outreach activity could be to discourage the consumption of fish high in mercury. However, although the state has data on methylmercury in small fish in the Bypass, it has no information on sizes and species consumed by people. A possibly useful activity would be to collect data on species targeted by people and, if the levels are above recommended levels, post notices at popular fishing sites.

Benefits

Outreach and education provide relevant information to people regarding the condition of their environment, the impacts that such conditions may have on them, the impacts they may have on the environment, and options for how to change their practices. Outreach can be an effective means of pollutant reduction and risk reduction for humans. Education provides the foundation for outreach, while also encouraging decision-makers and the people they serve to implement additional control measures.

Focused interactions among responsible authorities improve efficiency and consistent understanding of responsibilities for protecting water quality.

Costs

Effective public outreach campaigns for municipalities the size of Davis and Woodland would cost on the order of $100,000 per year (Elzufon, 2000). Agency collaboration activities require staff time, but presumably are balanced by improved operating efficiency. Outreach to potential swimmers in the Bypass could be accomplished through fliers distributed to farm workers and notices on message boards at the Yolo Basin Wildlife Area.

Other Considerations

While outreach and education can be fairly effective in comparison to the cost, it does not usually solve a water quality issue on its own. In addition, such campaigns take time to change the behavior of the general population. However, it remains an important element of any management plan and should not be overlooked. More focused outreach activities are described elsewhere in this report.

2 Reduce Local Groundwater Use

Municipalities and agriculture within the Yolo County region rely on local groundwater resources as a water supply for municipal and irrigation uses. Groundwater in the area is known to contain high levels of salinity and boron. Therefore, by using groundwater as a source of water supply, municipal discharges and irrigation return flows automatically contain higher levels of such constituents. Consequently, one control measure to reduce such inputs would be to reduce the use and reliance on local groundwater by developing other water sources or by reducing demand.

2.a Develop Alternative Water Supplies

POCs addressed: boron, salinity

Description

Typical salinity levels measured in City of Woodland wells (LWA, 2003; pers. comm. Christine Engel, City of Woodland to S. McCord, 3/5/05) are:

- Supply wells = 900-1100 umhos/cm
- POTW influent = 1650-2000 umhos/cm

Assuming a fixed increase in salinity, municipal uses commonly increase salinity by approximately 550 umhos/cm. Lower hardness supply water should result in a smaller decrease in salinity as softener salts can be dosed less and soaps work better.

Recognizing that groundwater is the dominant source of high hardness and salinity in irrigation tailwater and POTW effluent, reducing the flow from that source by developing alternative water sources is a potential solution. Alternative sources are described here.

- Sacramento River – Sacramento River water[1] has an average conductivity of 140 umhos/cm.
- Deep aquifer groundwater wells that are less saline – such wells in the City of Davis produce water that has an average conductivity of 550 umhos/cm.

Installing deep aquifer wells as a means to reduce salinity in the UC Davis campus wastewater is not an option because all domestic wells serving the campus are already in the deep aquifer.

Benefits

Based on the salinity levels given above, POTW influent EC would be in the range of 700-1600 umhos/cm if Sacramento River water were the supply source, depending on the blend of supplies that could be provided. As a result, wastewater effluent would be considerably lower in salinity and would therefore not be of concern for agricultural or municipal uses of the effluent.

The City of Davis and UC Davis campus have already tapped into deeper wells to try and reduce the salinity of their water supply. However, the use of such wells does not solve the salinity issues for the municipal wastewater dischargers. For example, POTW influent EC would be in the range of 1100-1600 umhos/cm if deeper well water were used as a supply source, depending on the blend of supplies that could be provided.

Costs

In order to obtain a surface water supply, the municipalities must go through the State Water Resources Control Board and obtain an appropriative right, or contract with other entities that currently have surface water rights. In either case, the Cities, UC Davis, and agricultural water suppliers would incur costs associated with this process. In addition, surface water supplies may cost more per acre foot then the cost that is currently associated with groundwater pumping costs.

Installation costs for new wells tapping the deep aquifer cost on the order of $1.2 million (pers. comm., David Phillips, UC Davis, to S. McCord, 2/10/05). The cost of installing deep aquifer wells for agricultural groundwater users may not be practical.

Other Considerations

Besides a potential cost increase, the ability to successfully obtain rights to a surface water source for water supply is not guaranteed. As the population in California continues to grow,

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[1] Based on measurements at Veteran's Bridge reported in the Coordinated Monitoring Program's 2003 Annual Report, available on-line at http://www.srcsd.com/pdf/rpt-cmp-03.pdf.

there are additional demands on California's surface water supplies. As a result, obtaining surface water rights is a competitive process that offers no guarantees.

Another consideration is the actual need for municipalities to obtain alternative sources of water in order to reduce salinity in the effluent. Currently, the primary beneficial uses that are driving the issue are municipal and agricultural uses. The drinking water level for municipal uses is set at 900 umhos/cm and the most conservative number currently used for agriculture is 700 umhos/cm. Both of these water quality standards may or may not be appropriate under the current circumstances.

For example, the 900 umhos/cm for municipal uses applies to Putah Creek and therefore the University of California, Davis' discharged effluent. It is based on the secondary maximum contaminant level (MCL), which is a consumer acceptance taste and odor standard and not a public health level.

The 700 umhos/cm level for agriculture is subject to even further questions of applicability in this area. The standard comes from a United Nations study that recommends water quality goals and guidelines. The 700 umhos/cm is the most conservative recommended standard for the most salt sensitive crops in all climates throughout the world, including arid and desert regions. It does not account for natural conditions, actual crops grown or rainfall. As a result, studies are currently underway to determine what may be an appropriate standard for the Yolo Bypass area considering all the necessary factors. The studies are being conducted by researchers at the University of California, Davis.

In addition to the studies, the local agricultural community is not convinced that 700 umhos/cm is necessary for the crops grown in and near the Bypass. The agricultural community appears to be more concerned with potentially losing the irrigation water created from these discharges then with receiving irrigation water with a slightly higher level of salinity.

Residential development in Lake County may develop surface water storage. These reservoirs could provide some additional relatively low salinity water to Cache Creek during the dry season.

2.b Reduce Urban Water Demand

POCs addressed: boron, salinity

Description

Groundwater pumping for urban areas could be reduced by reducing water demand directly or by expanding local water reuse to effectively reduce demand for new water. One potentially effective tool is the installation of water meters and water use fees based on use rates.

Benefits

Salt and boron loads introduced from groundwater aquifers could be reduced by reducing groundwater use and subsequent discharge.

Costs

Minimal costs to municipalities would be incurred for conducting outreach and education to reduce water demand.

Residents can purchase improved technologies for plumbing fixtures, washing machines, irrigation systems, and water heaters. Industrial and commercial units can install low-flow toilets and high efficiency cooling towers. Costs associated with designing, constructing and operating local water reuse systems are undetermined.

Increased energy efficiency tends to balance costs of irrigation controller systems and indoor technologies (DWR, 1998). Similarly, WWTP treatment costs could be slightly reduced for the lower influent flows.

Other Considerations

The net result of reducing water use would be to reduce discharges to local waterways. However, the salt concentration in POTW influent would be slightly higher as the slightly lower load of salinity added in the service area would be concentrated in proportionally less influent water. As a result, the effluent load of salinity would also be increased. Consequently, the advantage of increased water efficiency may not improve water quality. In addition, the loss of effluent may negatively impact the agricultural community that relies upon the effluent discharge for irrigation purposes.

Local agencies are required by the 1990 Water Conservation in Landscaping Act to enforce ordinances intended to promote water-efficient designs. The Act's requirements apply to landscapes greater than 2,500 square feet in area.

DWR (2000) deferred implementing regional scale urban water conservation options, reasoning that no significant depletion reductions were attainable.

3 Reduce POTW Influent Loads

POTW influent loads of some POCs can be reduced by focusing on the major sources of those POCs. This section describes several control measures that could be implemented within POTW service areas to reduce influent POC loads. These measures would consequently reduce POTW effluent loads.

3.a Encourage Alternatives to Conventional Water Softeners

POCs addressed: salinity

Description

The typical self-regenerating water softener operates by removing the ions contributing to hardness with an ion exchange resin column. Over time, the column becomes saturated with the hardness ions, and it becomes necessary to replenish the sodium ions via regeneration. By passing a strong brine solution (about 3 pounds of salt per gallon, equivalent to approximately 360,000 mg/L) through the bed, the hardness ions are overwhelmed by the strength of the sodium ions and are driven off the bed. At the end of the process, the waste brine is discharged to the sanitary sewer. The waste brine is a source of salts discharged to POTWs.

Salts can be reduced in POTW influent by implementing tighter controls for water softeners, and perhaps new pre-treatment technology for some industrial equipment (e.g., boiler feed water). Alternatives to self-generating water softeners include portable tank exchange services, magnetic / electronic / catalytic water conditioners, reverse osmosis, carbon filtration, and distillation. Similar alternatives to conventional softeners could also be applied at wellheads rather than at individual buildings.

Benefits

UCD has estimated that a 3-10% reduction in POTW influent salinity may be possible by incorporating advanced technology for boiler feed water and other major water uses (pers. comm., D. Phillips).

It is estimated that the Cities of Davis and Woodland combined may be able to reduce total salt loads to the Bypass by approximately 5,000 pounds per day if 40% of the households with self-generating water softeners would replace such systems. This is assuming that there are 40,000 households in Davis and Woodland combined and that 20% of households have self-regenerating water softeners.

Costs

Rebates, credits and buy-back programs can be used to promote alternatives to conventional water softeners. Assuming 40,000 households in Davis and Woodland combined, 20% of households have self-regenerating water softeners, 40% of those households would decide to participate in the program, and $800 for providing an alternative softener system, total costs for implementing a water softener replacement program would be approximately $2.5 million if it is assumed that a $800 rebate is given to 40% of the households with self-regenerating water softeners.

Other Considerations

Brine produced by softening all potable water and disposal of brine from wellheads distributed throughout the municipalities would be problematic.

Municipalities could ban water softeners for new development. Although they cannot legally ban existing water softeners, they may be able to provide incentives for alternatives. However, alternatives can be expensive to purchase and maintain. Any brine, precipitate or filters must be disposed rather than discharged back to the sanitary sewer.

3.b Outreach on Proper Operation of Water Softeners

POCs addressed: salinity

Description

For wastewater dischargers into the Yolo Bypass, salinity issues are of the greatest concern. A large source of salinity in wastewater comes from self-generating water softeners. Outreach and education to members of the public regarding the impact of inefficient water softeners could help to reduce salt loads significantly.

Benefits

If only 40% of the households participated in a program to increase water softener efficiency (assuming 40,000 households in Davis and Woodland combined and 20% of the households having self-regenerating water softeners) each of those participating systems could be made 10% more efficient, total salt loads to the Bypass could be reduced by approximately 500 pounds per day.

Costs

Effective public outreach campaigns for municipalities the size of Davis and Woodland would cost on the order of $100,000 per year (Elzufon, 2000). Such a campaign could incorporate multiple elements besides water softeners.

Other Considerations

None identified.

3.c Conduct Mercury-specific Outreach and Education

POCs addressed: mercury

Description

Mercury's unique chemical characteristics, sources and environmental impacts may require special control measures. Potential control strategies identified for mercury are listed in Table 2.

Table 2. Potential Mercury Source Control Strategies.

Potential Source	Control Strategy
Dentists	Business outreach with BMPs; regulate
Household products (thermometers, contact lens solution, fluorescent light bulbs)	Outreach to pharmacies; public thermometer collection program; fluorescent light bulb exchange program
Hospitals; laboratories	Outreach; sewer line cleaning
Laundry	Promote graywater systems

Benefits

It is difficult to quantify the potential benefit that municipalities in the bypass may obtain by implementing the control strategies above. However, examples from other POTWs may provide a useful illustration of potential benefits.

First, the City of Palo Alto quantified its annual influent loading of mercury by source (Elzufon, 2000). These potentially controllable sources represented approximately 30% of the total influent mercury load. Assuming that these loads could be reduces by approximately 50%, the potential total influent load reduction by implementing all of these control strategies would be on the order of 15%. The resulting reduction in effluent load would be 0-15%. The low end of this range is in recognition that a reduction in influent mercury load does not necessarily translate into reduction in effluent load.

Second, the Sacramento Regional County Sanitation District (SRCSD) has implemented an effective mercury reduction program that could be mimicked in the Yolo Bypass watershed[2]. SRCSD's residential mercury outreach and collection efforts have resulted in the removal of an estimated 18.5 pounds of elemental mercury and approximately 192 pounds of mercury and

[2] See the "Be Mercury Free" website at http://www.bemercuryfree.net/index.html.

mercury-containing products over the past two years. Scaling these values by the proportional populations (~100,000 in the Davis and Woodland communities versus ~1 million in the Sacramento service area), local outreach efforts would result in approximately 2 pounds of elemental mercury being collected. The proportion of this mercury that would have eventually entered local waterways is uncertain.

Costs

Costs to POTWs for implementing these control strategies are primarily associated with staff time needed for interact with businesses such as dentists, pharmacies and hospitals that may not be regulated currently. Public outreach activities would require educational materials and staff resources as well. There may also be some costs associated with monitoring the collection system to better determine the amount of mercury that is entering the POTW from the various areas of the collection system.

Other Considerations

The City of Woodland is currently surveying local dentists to determine current mercury reduction efforts.

Both POTW effluent and urban stormwater would benefit from these outreach activities. However, POTW effluent is not considered to be a major source of mercury to the Bypass and therefore may do little to address this water quality issue.

3.d Enhance Industrial Pretreatment

POCs addressed: aluminum, mercury, salinity

Description

Pretreatment programs for industries such as vehicle service facilities, printers, and commercial car washes can reduce metals loads to sewers. Food processing industries often discharge high salt loads that could be reduced.

Benefits

Load reductions of 30-99% for many heavy metals (e.g., copper, mercury, lead, silver, zinc) can be achieved by such facilities. The resulting percent reduction in POTW influent depends on the relative contribution of industries.

Costs

Effective pretreatment programs for municipalities the size of Davis and Woodland cost on the order of $50,000 per year (Elzufon, 2000).

Other Considerations

The City of Davis, in particular, is a residential community with a small industrial base. The industrial pretreatment programs for both the Cities of Woodland and Davis prioritize BOD, solids, fats, oil, and grease for pretreatment. Local limits for City of Woodland’s four Significant Industrial Users include the pollutants of concern mercury and DDT. The City of Davis and UC Davis campus do not have local limits.

Industries that tend to produce high-salinity wastewater include, for example, textiles, food processors, and petroleum refineries. None of these or similar industries exist on a large scale in the watershed. Thus, industrial pretreatment local limits for salts would have negligible benefits on salinity in POTW effluent.

4 Enhance POTW Treatment

Three advanced wastewater treatment technologies are discussed in this section:

- Tertiary treatment;
- Carbon adsorption; and
- Microfiltration – reverse osmosis.

Other technologies such as nitrification-denitrification and ultraviolet disinfection would not address high or medium priority POCs.

4.a Install Tertiary Treatment

POCs addressed: aluminum, bacteria, mercury, organic carbon, pesticides

Description

Primary treatment of wastewater reduces oils, grease, fats, sand, grit, and coarse (settleable) solids. Secondary treatment of wastewater means biological oxidation to reduce further BOD and suspended solids concentrations. Tertiary treatment of wastewater provides additional treatment for more specific water quality benefits. Common tertiary treatment processes include filtration, polishing wetlands, and biological filters for denitrification.

Benefits

Organic pesticides and inorganic compounds such as nitrogen, sulfides, and heavy metals are generally reduced to nondetected levels by tertiary treatment.

Costs

The City of Woodland estimated that total 20-year life-cycle costs to upgrade to tertiary treatment would be approximately $20 million (ECO:LOGIC Engineering, 2003).

The UC Davis campus wastewater treatment facility operates a tertiary treatment facility. The filters cost approximately $1.8 million for the current 2.5 MGD design flow rate (pers. comm., David Phillips, UC Davis, to S. McCord, 2/10/05). Operation and maintenance costs will result in similar life-cycle costs as for the City of Woodland.

Other Considerations

Because tertiary treatment processes tend to target specific pollutants, systems must be designed to address specific concerns and cannot be expected to reduce effluent concentrations of other pollutants.

4.b Install Microfiltration – Reverse Osmosis Filters

POCs addressed: boron, salinity

Description

Microfiltration following tertiary treatment produces effluent suitable as a feed source for reverse osmosis. Reverse osmosis (RO) is a water treatment technology that utilizes membrane filters to remove dissolved substances. This control measure only addresses constituents that were not removed by tertiary treatment. Water is separated from dissolved salts in solution by filtering through a semi-permeable membrane at a pressure greater than the osmotic pressure caused by the dissolved salts in the wastewater.

Benefits

High-salinity effluent can be treated to reduce salinity as well as other particulate and dissolved compounds. An RO system could be operated at moderate performance levels to simply improve conditions, or at maximum efficiency to produce potable water.

Costs

The major costs associated with RO systems include construction, operation, and brine disposal. Approximate costs for Florida (United States Navy, 2005) are:

- Construction ($mil/MGD capacity): 1.4-2.1
- Operation and maintenance ($/million gallons of production): 1,060-1,550

Total costs approximated for a 10 MGD facility with a 20-year life cycle and not discounted would be $5-7 million per year. A deep well in which to inject the brine would cost on the order of $1 million.

The City of Woodland estimated that total 20-year life-cycle costs to treat approximately half of its wastewater through RO filters and evaporate the brine would be approximately $110 million (ECO:LOGIC Engineering, 2003).

Other Considerations

The major constraints to installing and operating RO systems include:

- Disposal of a continuous waste stream of RO brine (the process water that does not pass through the filters) is especially problematic in inland areas. Brine could be injected into deep wells. Potential impacts on groundwater aquifers are unknown. Piping or otherwise transporting brine to the ocean is not perceived to be a realistic option;
- Effluent discharges are reduced by approximately 20%, decreasing water supply available to current water users in the Bypass; and
- Operation of RO systems requires higher energy for pressuring the process water.

Because the major water supplies for the Cities of Davis and Woodland are groundwater, wells are decentralized. A separate piping system to remove and treat the brine from each of the dozens of wells would require an entirely new piping system. Brine injection wells would each cost on the order of $1 million to construct and operate.

5 Improve Urban Storm Water Management

Water quality studies have shown impacts on receiving water caused by stormwater runoff from impervious surfaces. Pollutants associated with residential, commercial and industrial activities in a watershed include sediment, fertilizers, pesticides, other chemicals, paints, waste oil, other vehicle fluids, petroleum hydrocarbons, heavy metals, and coliform from human and animal wastes. Stormwater runoff that comes in contact with these pollutants are transported quickly and efficiently to and through the stormwater sewer system and discharged to receiving waters. In addition, stormwater runoff rates and quantity may significantly increase as a result of impervious surfaces cause by new development.

Stormwater discharges are regulated in California by NPDES permits. Separate permit programs relevant to the local Yolo Bypass watershed are described here.

- The Cities of Davis, Woodland, and West Sacramento, the County of Yolo and the UC Davis campus are regulated under Phase II of the NPDES General Permit for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems. Their stormwater management programs will be fully implemented by 2008.
- Construction sites disturbing greater than 1 acre of land are required to comply with the statewide NPDES General Permit for Discharges of Storm Water Runoff Associated with Construction Activity.
- Qualifying industrial facilities are required to comply with the statewide NPDES Industrial Storm Water General Permit. The State Board web site[3] indicates that two facilities in Davis, 6 on the UC Davis campus, 28 in Woodland, and 3 in Winters actively participate in the industrial stormwater permit program.

Permittees regulated by these stormwater programs are required to reduce pollutant loads in their discharges to the maximum extent practicable. Specific activities expected to provide the greatest water quality benefits to the Bypass are described in this section.

Costs for municipal stormwater programs are difficult to distinguish from normal practices. A recent survey by the California Stormwater Quality Association found costs ranging from $18 to $48 per household (pers. comm., Brian Currier, CSUS, to S. McCord, 3/9/05). Descriptions of costs associated with specific program elements described in this section are provided only for initial guidance.

5.a Minimize Effects of New Development

POCs addressed: bacteria, organic carbon, pesticides

Description

The Small MS4 General Permit requires municipalities to develop, implement and enforce a program for stormwater runoff from new development and redevelopment projects that result in land disturbance of one acre or more to prevent and minimize water quality impacts. The program must include a plan to implement site-appropriate and cost-effective treatment and source BMPs and ensure long-term operation and maintenance of such BMPs. The Small MS4 General Permit requires the City to adopt a set of design standards for certain development categories.

[3] Site accessed on January 19, 2004 at http://swrcbnt3.swrcb.ca.gov/stormwater/search/IndSearch.asp.

Benefits

Impacts to water quality and the physical and biological characteristics of an aquatic habitat caused by new development can be minimized through implementing post-construction stormwater BMPs. BMP handbooks such as those available from the California Stormwater Quality Association[4] provide some measure of removal efficiencies for various BMPs. Removal efficiencies depend greatly on site-specific conditions.

Costs

Costs for developers to incorporate stormwater BMPs are difficult to distinguish from normal practices. Revising design standards, training staff, revising municipal code, and inspecting and maintaining facilities increase costs for municipalities. Additional land requirements for structural BMPs require more land. A recent survey by the California Stormwater Quality Association found costs ranging from $**[available in late February] per household for new development.

Other Considerations

None identified.

5.b Outreach to Minimize Stormwater Impacts

POCs addressed: aluminum, bacteria, boron, mercury, organic carbon, pesticides, salinity

Description

Outreach in urban areas is required for permitted municipal stormwater management programs. Municipal stormwater outreach activities that could be promoted and the POCs that they address are:

Activity	POCs Addressed
Promote use of “doggy bags”	Bacteria
Announce bulk waste collection dates	Organic carbon
Announce hazardous waste collection events	Metals, pesticides
Conduct general stormwater awareness campaigns	All
Efficient operation of lawn irrigation systems	Boron, pesticides, salinity
Promote IPM programs and appropriate residential pesticide applications	Pesticides
Provide containerized green waste pick-up	Organic carbon

[4] Available on-line at http://www.cabmphandbooks.org/.

Benefits

The benefits of stormwater-related outreach are difficult to quantify because they depending on several factors such as current level of awareness, the design and timing of the campaign, and the imprecise relationship between the polluting activities and water quality impacts.

Several of the activities described are already practiced in the Cities of Davis and Woodland, so the additional benefit derived from increased awareness are uncertain.

Costs

Effective public outreach campaigns for municipalities the size of Davis and Woodland would cost on the order of $100,000 per year (Elzufon, 2000).

Other Considerations

Green waste containers would be most useful in the City of Woodland, and such a program is being implemented in the new portions of the City. The remainder of the City will be phased into the program. Discharges from the City of Davis are largely captured in stormwater detention ponds, in which organic carbon is not identified as a pollutant of concern.

6 Improve Rural Land and Water Management

Rural land management focuses on agriculture but also includes other non-point source rural areas. For agriculture, control measures typically take the form of management practices for crop cultivation, irrigation and pesticide applications. While the Regional Board can not require specific BMPs, they can requires that agricultural and other nonpoint source dischargers implement BMPs. Up until recently, the Regional Board had allowed agricultural dischargers to operate under a waiver of the requirement to file a report of waste discharge. The revision of the California Water Code that dealt with waivers forced the Regional Board to rescind the old waiver and develop a new one that complied with the new law. The new waiver requires agricultural dischargers to comply with water quality standards and allowed such compliance through the individual or group development of water quality management plans. It is anticipated that water quality management plans developed for this purpose will identify various management practices that are designed to address the pollutant (or pollutants) that is causing a violation of an applicable water quality standard. The development of a water quality management plan that is specific to agriculture in the area should be considered to be a control measure.

While it is not feasible to identify all of the potential management practices because of the variability in agriculture in and near the Yolo Bypass, several common control measures are identified and discussed below.

6.a Construct or Improve Settling Basins

POCs addressed: aluminum, mercury, pesticides

Description

Settling basins are essentially a specialized type of treatment wetland. Additional opportunities – or lack thereof – for installing new basins or optimizing the sediment removal efficiency of existing basins are as follows:

- The Cache Creek Settling Basin's sediment removal efficiency could be increased by raising the weir height or at least maintained by regularly excavating accumulated sediment.
- The 100-acre UCD Arboretum Waterway serves as a settling basin for campus runoff. All stormwater runoff from the central campus is routed into the Arboretum Waterway. Water collected in the channel largely infiltrates into the local aquifer. During a storm event, water from the Arboretum Waterway spills over a weir at the west end and large pumps send the water via pipeline into the South Fork of Putah Creek. Water in this basin could be pumped to and treated at the campus wastewater treatment facility during off-peak periods.

Because Lake Berryessa and Lake Solano trap the vast majority of sediment from the Putah Creek watershed, a settling basin near the mouth of Putah Creek would be redundant and ineffective. Approximately two-thirds of land within the City of Davis drains into retention ponds. The ponds are managed primarily to control floodwaters and maximize removal of particulates before discharging to agricultural drains. Wildlife and vegetation in these ponds are regularly monitored. Excavation of sediments within the Bypass is not necessary because sediment does not appear to be accumulating.

Benefits

Maintaining the Cache Creek Settling Basin at approximately maximum efficiency would remove, on average, an estimated additional 50 pounds per year of total mercury from entering the Bypass, compared to not maintaining the Basin.

Water quality benefits to Putah Creek and the Delta from treating the Arboretum Waterway would be negligible. The primary benefits would be improved water quality in the Arboretum and the potential for local water reuse.

Costs

The lowest-cost alternative is to maintain the existing Cache Creek Settling Basin. Maintenance costs are estimated to be as high as $15 million[5], but depend greatly on feasible soil disposal and reuse options.

Planning, design, and construction of the project to process water from the Arboretum Waterway through the campus wastewater treatment facility will cost approximately $350,000.

Other Considerations

The State of California, acting through DWR, is responsible for maintaining the Cache Creek Settling Basin. The Delta mercury TMDL being developed in 2005 could require maintenance of the basin as a component of the implementation strategy.

Additional study to be recommended in the management plan calls for measuring sediment accumulation rates in various regions of the Bypass.

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[5] Present-worth cost assuming a 30-year project life cycle, assuming the soil is disposed at the Yolo County landfill.

UC Davis facilities engineers are currently planning a project to reroute treated water from the Campus Wastewater Treatment Plant through the Arboretum Waterway to provide a source of fresh water during dry weather.

6.b Enhance IPM Programs

POCs addressed: pesticides

Description

Integrated pest management (IPM) is "an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties. Pesticides are used only after monitoring indicates they are needed according to established guidelines, and treatments are made with the goal of removing only the target organism. Pest control materials are selected and applied in a manner that minimizes risks to human health, beneficial and non-target organisms, and the environment."[6] To the extent that IPM programs decrease the use of broad spectrum pesticides, it can be an effective control measure for some pesticides that have been identified as a pollutant of concern.

Benefits

IPM targets the pests of concern and tries to avoid using broad spectrum pesticides.

Costs

Other Considerations

IPM may not be appropriate in all circumstances. Occasionally there are wide spread pest infestations that can not be controlled through the use of IPM.

6.c Enhance Irrigation Water Management

POCs addressed: pesticides, salinity

Description

Irrigation water can be managed differently to potentially reduce salinity and pesticide concentrations in tailwater. Adoption of new irrigation technology to reduce applied water will most likely result in a reduction of deep percolation, tailwater runoff, evapotranspiration (ET), or leaching effects. Reductions of deep percolation and tailwater runoff can be achieved by improving irrigation water application and management. ET can be reduced by minimizing irrigating with minimal loss in productivity. However, a reduction in irrigation water may further concentrate salt levels in the soil causing greater damage to crops then using more, high salinity irrigation water. When water is high in saline, one management practice to maintain crop yields

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[6] Taken from UC Davis, Division of Agriculture and Natural Resources website, www.ipm.ucdavis.edu/IPMPROJECT.

is to increase the amount of water used for irrigation in order to ensure that salt is not accumulating in the root zone.

Benefits

Longer holding times would reduce concentrations of degradable pesticides but increase salinity concentrations through evapotranspiration. Shorter holding times would have the opposite effect.

Costs

Recycling water is an efficient process that reuses local water supplies. Using “new” water to irrigate fields would cost more to withdraw water from farther and lower locations. Within the Bypass, the typical scenario would be west-side farms needing to pump from the east-side Tule Canal or Toe Drain.

Other Considerations

Leaching generally cannot be reduced because it would result in soil salinization, rendering the soil less productive and consequently reducing water use efficiency.

6.d Optimize Pesticide Applications

POCs addressed: pesticides

Description

Application practices could be optimized to minimize pesticide loads to water by using any or a combination of several methods:

- Use new sprayer technologies;
- Calibrate sprayer equipment more frequently;
- Use unidirectional spray equipment on the outer rows (to spray only in toward the crops);
- Not spray when rain is in the near-term forecast;
- Use drift retardants;
- Apply pesticides only in alternate years;
- Target pesticide applications only to areas with infestations; and
- Improve mixing/loading procedures.

In summary, a wide variety of options are available to farmers in response to efforts to reduce runoff of pesticides that are potentially harmful to water quality. The precise suite of management practices adopted by a given farmer would vary, but could be chosen in a manner to minimize the off-site movement of pesticides.

Benefits

Implementing improved pesticide application practices would result in more uniform applications at the most appropriate rate. Lower pesticide application rates would save money. Pesticide loads to local waterways would decrease by implementing this control measure.

Costs

Additional time and expense would be needed to install upgraded equipment and implement improved practices. No cost figures have been generated. Potential reductions in crop yields caused by reduced pesticide use have not been quantified, but are expected to be minimal.

Other Considerations

None noted.

6.e Restrict or Change Pesticide Use

POCs addressed: pesticides

Description

One control measure that is often raised when addressing the issue of pesticides is further restricting (or banning) the use of a specific pesticide. This control measure is currently applied to urban uses of the organophosphate pesticides chlorpyrifos and diazinon. Discharge prohibitions[7] apply to orchards in the Sacramento River watershed, which apply diazinon during the dormant (winter) season.

One alternative to water-soluble organophosphate- and carbamate-based pesticides in fields that that drain directly into waterways is pyrethroid-based pesticides. These tend to be less water-soluble, resulting in lower concentrations in irrigation tailwater (Freeman Long et al., 2002). However, there are concerns regarding the sediment toxicity of pyrethroids. If adsorbed to eroded sediments, control measures such as buffer strips or fescue in drains would minimize off-site transport.

An alternative to diuron-based herbicides is Roundup. A Roundup-ready alfalfa is coming to market in 2005. Paraquat, containing gramaxone as its active ingredient, is a contact herbicide rather than a pre-emergent herbicide applied to prevent seed germination. This type of chemical and its application tends to reduce losses to local waterways. An alternative to methomyl is Steward (indoxycarb is its active ingredient), which appears to have lower toxicity to aquatic life (pers. comm., Rachel Long, UCD Cooperative Extension, to S. McCord, 2/1/05).

Benefits

In most cases, the elimination of use should eliminate the pesticide of concern from the Bypass.

Costs

While there may be little cost to actually implement a restriction, there will be indirect costs that result from the pesticides elimination. For example, crop yields may decrease due to an increase in pests and disease; the use of alternative pesticides may be more costly for growers; and the research and development costs for replacement products is extremely costly.

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[7] The applicable TMDL document is available on-line at http://www.waterboards.ca.gov/centralvalley/programs/tmdl/sac_feather_diaz/FinalStaffRpt.pdf.

Other Considerations

In California, the governmental agency with sole jurisdiction to implement such a control measure is the California Department of Pesticide Regulation. Local governmental entities and the Regional Water Quality Control Boards do not have the legal authority to restrict the use of pesticides.

The elimination of some pesticides may result in the increased application of more environmentally harmful pesticides. For example, the organophosphate pesticides (chlorpyrifos and diazinon) are considered to be broad spectrum pesticides that dissipate fairly quickly in water. As the use of these crop protection chemicals becomes more restrictive, growers are turning to alternative pesticides. In some cases, the alternatives are pyrethroids for which little information is available. The pyrethroids do not usually impact water column concentrations but may be more prevalent in the soil since these compounds bond very tightly to soil. Consequently, the pyrethroids may exist in the environment much longer then other pesticides.

In addition, the elimination of use does not automatically mean that the pesticide will disappear from the environment. There are several pesticides that are creating concern even though they have been banned for a number of years (e.g. DDT).

6.f Minimize Erosion and Sediment Transport to Waterways

POCs addressed: aluminum, bacteria, mercury, organic carbon, pesticides

Description

Three control measures that minimize erosion and sediment transport from agricultural lands are commonly promoted locally, as described below[8].

- Double-section design tailwater ponds are designed such that silt-laden irrigation tail water and storm runoff enters the first pond (narrow trench design) which functions as a sediment trap. Captured silt is easily reincorporated into the field each fall. Nutrient-laden water exits this sediment pond via drop pipe inlet to the second, a recharge/return pond. Nutrients can be removed from tailwater by aquatic and shore plants before release into lower fields, drainage canals, or natural sloughs.
- A grassed waterway/vegetated filter system is a natural or constructed vegetated channel that is shaped and graded to carry surface water at a non-erosive velocity to a stable outlet that spreads the flow of water before it enters a vegetated filter. They can be constructed where water concentrates and gully erosion is a problem.
- A riparian forest buffer is an area of trees and shrubs located adjacent to water bodies. These areas have year-around and seasonal water available. They minimize streambank erosion, provide a wind buffer to adjacent properties, and they provide wildlife habitat.

Erosion control could be improved for farmland throughout the watershed. For the Willow Slough watershed, a total of 2,440 acres of actively farmed cropland could be converted to

[8] These and other control measures are described in the NRCS web site at http://www.ca.nrcs.usda.gov/programs/buffer.html. These specific measures were suggested by Arturo Carvajal, USDA/NRCS Water Management Specialist Engineer.

tailwater ponds, riparian corridors, or large perennial wetlands. This is approximately 3.5% of the active cropland in the watershed (Jones and Stokes, 1996).

The major source of mercury to the Bypass is mercury-laden sediments. A large but poorly quantified portion of this sediment is eroded native soil, while more contaminated soils emanate from historical mining areas. Erosion from lands managed by the US Bureau of Land Management will be reduced through appropriate restrictions on livestock grazing, surface mining, and off-road vehicle use (USBLM, 2004).

Benefits

A Pilot Program funded by CALFED and conducted by Yolo County RCD found that newly dug traps removed 98% of incoming sediment in the first irrigation (which caused most soil erosion). The percent of sediment captured during the growing season in tailwater ponds studied ranged between 11 and 97%. In the one tailwater pond built in combination with a sediment trap, combined sediment capture was consistently higher, ranging between 46 and 99% (pers. comm., A. Carvajal to S. McCord, 1/24/05). The types and relative proportions of benefits for a given pond depend on location, design, and duration of impoundment.

In tail ditches, portable canvas dams slow runoff and collect sediments that may extend the utility life of the sediment traps, which need to be excavated to entrain new sediments. Sediment traps that are properly maintained and built in combination with a tailwater pond sediment collection become more effective and the life of the pond is increased.

Sediment traps and filters also tend to remove bacteria through the processes of filtration and degradation. Removal rates of 95% for total coliform are common[9].

Costs

Trap installations cost approximately $600 to $1,000, including cost of flashboard risers, culverts and excavation. Pond construction cost depends on pond size and type of return system (if included). The range of costs found in the Yolo County area for ponds with capacities between 1.5 and 4 acre-feet is $4,000 to $12,000 for pond and inlet/outlet structures. Addition of native vegetation on the area around the pond would add an additional $1,000 to $3,000 for material, labor, and irrigation system (pers. comm., A. Carvajal to S. McCord, 1/24/05). Filter strips and riparian buffers would cost on the order of $500 per acre per year to construct and maintain[10].

Assuming local farmland has a value of $250 per acre per year[11], the cost associated with converting productive agricultural land to use as a control measure on 2,440 acres would be on the order of $610,000 per year.

Other Considerations

While tail water recovery ponds and other sediment impoundments can work effectively to minimize pollutants entering the waterways through sedimentation and erosion, many growers are concerned about the loss of productive agricultural land and potential liability associated with the creation of additional wildlife habitat. Once habitat has been created on agricultural land, it becomes difficult to remove the habitat due to other environmental regulations and laws

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[9] Referenced on-line at http://www.wsi.nrcs.usda.gov/products/waterborn-pathogens.html.

[10] Cost estimate is adjusted from 1995 to 2005 costs, and adapted from NRCS (1995).

[11] Cost estimate provided by the California Chapter of the American Society of Farm Managers and Rural Appraisers, available on-line at http://www.calasfmra.com/landvalues/2003/Reg01.pdf.

such as the state and federal Endangered Species Acts, state streambed alteration laws, and Corps of Engineer regulations governing wetlands. Growers and their neighbors are concerned that such control measures may attract endangered species to their property, therefore creating the potential liability for taking the species during the course of normal, cultural practices. Growers are also concerned that once created, growers lose flexibility to alter cropping practices and patterns because now the habitat may be considered a water of the U.S. or state and therefore require some sort of permit for removal.

In addition, above-grade impoundments always pose a risk of dam failure. Crops could be eaten by wildlife inhabiting wetlands. Flooding of fields can accelerate leaching of pesticides, herbicides, and nitrogen, thereby increasing the risk of groundwater contamination. Vehicle access to densely vegetated riparian reaches is difficult. On the plus side, actively managing riparian vegetation provides an opportunity to selectively remove problematic invasive weeds.

Erosion control within the Bypass is actually discouraged. The Bypass' flood conveyance capacity would be reduced if sediment were not flushed regularly.

6.g Remove or Stabilize Mine Waste

POCs addressed: mercury

Description

Various conventional technologies exist to reduce the load of contaminated sediments entering water bodies. These include:

- Erosion control – common practices such as drainage modifications, re-grading, re-vegetation and slope stabilization;
- Containment and stabilization/encapsulation – application of non-contaminated covering soils or encapsulation using soil stabilizers; and
- Removal and disposal – excavation and disposal in a landfill for highly concentrated mercury-containing wastes.

Benefits

Mine waste cleanup addresses contamination of local waterways from erosion and leaching, both at mine sites and in contaminated streambanks. Mine site cleanup will be required by the Cache Creek mercury TMDL for several mercury mines in that watershed. It is estimated that on the order of 95% of the current mercury load can be stopped through effective site remediation. However, the net load reduction of total mercury entering the Bypass would be approximately 5% of the total load from that watershed, thus less than 10 lbs/yr.

Costs

Remediation of the Sulphur Bank Mercury Mine by Clear Lake has taken over a decade and is still not completed. Costs to date exceed $12 million for remediation work alone, not including numerous studies over the past two decades.

Mine remediation projects in the Cache Creek and Lake Berryessa watersheds could cost on the order of $5 million per site, depending on the size of the site and local conditions.

Other Considerations

Many of the abandoned mercury mine sites are on land now owned and managed by the federal Bureau of Land Management (BLM). BLM would be responsible for cleaning up contaminated areas on those properties. Private landowners, who generally inherited similarly contaminated sites, would be responsible for their land. In both ownership situations, funding would be the primary concern.

There is currently considerable uncertainty regarding a third party's liability associated with cleaning up contaminated property. At a minimum, there would be a delay in evaluating a property owner's obligation and ability to conduct the remediation. The load reduction provided by a mine remediation project in the Cache Creek or Putah Creek watersheds would primarily benefit local water quality. Loads to the Bypass are already reduced significantly by deposition in streambanks, lakes and settling basins.

7 Manage Water Resources for Water Quality Benefits

7.a Minimize POTW Discharges to the Bypass

POCs addressed: salinity

Description

City of Woodland, City of Davis, and UC Davis campus POTW effluents with relatively high salinity are discharged into Bypass tributaries or directly into the Bypass. These sources could be applied to land seasonally or discharged instead into the Sacramento River.

The City of Woodland is investigating the viability of discharging its effluent directly into the Sacramento River near the Feather River confluence. The City of Davis is also investigating, as part of its Master Planning process, the viability of discharging its effluent directly into the Sacramento River south of West Sacramento.

Benefits

Salinity levels in the Yolo Bypass in the vicinity of removed POTW effluent discharges (Woodland or Davis) could decrease by approximately 25% during the dry season if POTW effluent were diverted out of the watershed.

Costs

Land application of wastewater would incur costs to purchase or lease the land (several hundred acres), install pipelines or irrigation channels, and manage the land and water. The City of Woodland estimated that total 20-year life-cycle costs to change its current method of effluent disposal from surface water discharge to reclamation via irrigation of fodder crops would be approximately $90 million (ECO:LOGIC Engineering, 2003). Offsetting benefits of increased land value and crop sales were not considered.

The City of Woodland estimated that total 20-year life-cycle costs to change its current effluent discharge point from Tule Canal in the Bypass to the Sacramento River would be approximately $18 million (ECO:LOGIC Engineering, 2003). Cost associated with installing and operating pipes from the City of Davis across the Bypass and through West Sacramento would be similar.

Other Considerations

Discharging treated effluent to land would not be effective during the wet season when soils are saturated. Although POTW discharges are used currently for irrigation, the more direct application to land is regulated more stringently. Recent NPDES permits in the Central Valley have increased treatment requirements for land disposal in recognition that the water could impact drinking water aquifers.

Growers in the Bypass rely on urban runoff and municipal wastewater discharges for irrigation purposes. Removing this water supply may harm local agricultural operations. Transferring POTW discharges to the Sacramento River would not reduce salt loads to the Delta.

7.b Manage Water Use in Bypass Wetlands

POCs addressed: aluminum, organic carbon, pesticides

Description

Wetlands have been found to effectively remove many pollutants if managed for that purpose. Various parcels within the Bypass are managed differently, creating a mosaic of wetland types. These lands can potentially be managed to improve water quality while also providing benefits such as flood retention, recreation, and wildlife habitat.

Benefits

Sediment removal efficiency in wetlands can vary with settling velocity of the particles and the hydraulic characteristics of the system, (e.g., retention time, depth, aspect ratio, percent open water area). However, wetland systems designed to remove other pollutants, such as nitrogen, typically will be over-designed with respect to suspended solids removal and systems can generally be expected to produce TSS levels close to background concentrations. Background concentrations are typically in the range of 3 to 15 mg/L and are the result of vegetation decomposition and wildlife activity. Many other POCs such as other metals, organic material and pesticides associated with sediments would also be removed.

Costs

Costs for altering wetland management practices would come from developing management plans and monitoring, in addition to any control structures. A managed wetland project would cost in the range of $20,000-$50,000 per acre (pers. comm., Tom Cannon, Wildlands, to S. McCord, 2/9/05).

Other Considerations

Residence time, seasonality of flows, soil types, plant communities, and influent quality can all impact pollutant removal rates.

Hardness and salinity, including boron, tend to increase through wetlands by the process of evaporative concentration. Heavy wildlife use of wetlands tends to increase fecal coliform concentrations.

In a national pilot study of mercury contamination in aquatic ecosystems, USGS found that wetland density (area of wetlands per area of watershed) was the single most important basin-scale factor controlling methylmercury production (Brumbaugh et al., 2001). The only local study on this issue found that the Cache Creek Nature Preserve wetlands functioned as a clear source of methylmercury to lower Cache Creek (Slotton and Ayers, 2004). The Delta mercury TMDL is expected to recommend that there be a no net increase in methylmercury loads from restored marshes and new water impoundments.

Because sulfate-reducing bacteria tend to drive the methylation process, it is believed that limiting the available sulfate could be a key to minimizing the rate of methylation. The most concentrated sources of sulfate are mineral springs in the Cache Creek watershed (Domagalski et al., 2004). However, the highest concentration of sulfate enters the Bypass through the Ridge Cut (Schemel et al., 2002).

Costs and potential benefits of projects to control methylation cannot be generated until specific projects are identified.

7.c Alter Inter-basin Water Transfers

POCs addressed: salinity

Description

Inter-basin water transfers refers to the delivery of water from one watershed (basin) to another. Two major options are considered:

- Much of the Colusa Basin Drain water is discharged into the Sacramento River. More water could be diverted from the Drain into the Knights Landing Ridge Cut, which discharges into the upper Bypass. It is assumed that this diversion of water into the Bypass may worsen water quality in the Bypass; however, until monitoring data is compiled and evaluated it is not possible to determine the actual impact this change in water management may have on the Bypass.
- A low-flow fish passage could be constructed in the Fremont Weir. Water from the Sacramento River would be diverted continuously through the passage, supplying relatively high-quality water to the Bypass.

Water from Putah Creek is diverted at Lake Solano and largely transferred out of the watershed to Solano County for irrigation and potable supply. Diverting less water could provide greater dilution in lower Putah Creek and in the lower Bypass. A settlement agreement provided 50% greater flows to lower Putah Creek, along with a winter “pulse” flow to encourage salmon spawning. However, because allocations of that water have been determined by court ruling, additional flows are considered relatively unavailable.

Benefits

Colusa Basin Drain water would provide additional water volume for irrigation.

Sacramento River water diverted through a low-flow passage in the Fremont Weir would provide some year-around diluting flow to the entire Bypass. There are no major water quality concerns with this source.

Costs

Designing and constructing a low-flow passage through the Fremont Weir and purchasing water rights would incur costs. Current activities are aimed at determining project feasibility and estimating these costs.

Other Considerations

Colusa Basin Drain water is generally considered to be of poor quality, although monitoring under this project did not find levels of concern for any POCs. There is nonetheless the potential for water quality in the Bypass to be negatively impacted by this source. Farmers in the Bypass are generally opposed to this project because of the potential for more regulatory concerns associated with the supply of poorer water quality.

Water diverted from the Sacramento River through a low-flow passage would be designated primarily for salmon migration. It would likely not be available for local irrigation.

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