STATE OF CALIFORNIA
STATE WATER RESOURCES CONTROL BOARD

In the Matter of the Petition of ROBERT JAMES CLAUS For Review of Inaction of California Regional Water Quality Control Board, Central Valley Region. Our File No. A-354.	ORDER NO. WQ 87-3

BY THE BOARD:

On April 27, 1984, Robert James Claus (petitioner) appeared before the California Regional Water Quality Control Board (Central Valley Regional Board) and requested the Central Valley Regional Board to take enforcement action against the United States Bureau of Reclamation (Bureau), the owner and operator of Kesterson Reservoir, and other entities discharging agricultural drainage in the western San Joaquin River basin. The Central Valley Regional Board declined to take the requested action, and on May 18, 1984, petitioner appealed this inaction to the State Water Resources Control Board (State Board or Board).

On October 15 and December 7, 1984, and January 8, 1985, the State Board held evidentiary hearings on petitioner's appeal. On February 5, 1985, the State Board adopted Order No. WQ 85-1 and Cleanup and Abatement Order No. 85-1. In these orders the State Board concluded that the Bureau was discharging waste at Kesterson which reached waters of the state and which caused or threatened to cause conditions of pollution and nuisance. The Bureau was, therefore, ordered to clean up and abate the effects of these discharges. Under Cleanup and Abatement Order No. 85-1 the Bureau was directed to submit a plan to the State Board by July 5, 1985, specifying the manner in which the Bureau would comply with the cleanup order.

The Bureau subsequently elected to comply with Order No. WQ 85-1 and Cleanup and Abatement Order No. 85-1 by closing Kesterson Reservoir, and on July 5, 1985, the Bureau submitted a Kesterson Reservoir Closure and Cleanup Plan to the State Board. This plan did not provide sufficient details on closure; consequently, on August 22, 1985, the State Board adopted Order No. WQ 85-5, directing the Bureau to submit a detailed final closure plan by December 1, 1986. In compliance with Order No. WQ 85-5 the Bureau submitted a Closure and Post-Closure Maintenance Plan (Closure Plan) for Kesterson Reservoir to the State Board on December 1, 1986.

On January 26 and 27, 1987, the State Board held an evidentiary hearing on the Bureau's Closure Plan. Key issues at the hearing were:

1. Does the Closure Plan comply with the requirements of State Board Order No. WQ 85-1, Cleanup and Abatement Order No. 85-1, and Order No. WQ 85-5?

2. Should the State Board approve the Closure Plan?

The State Board kept the hearing record open for receipt of additional written materials until February 2, 1987. On March 5, 1987, the State Board reopened the hearing record, at the Bureau's request, to permit the introduction of additional materials by the Bureau. Interested persons were allowed until March 16, 1987 to file responsive comments.

I. INTRODUCTION

Kesterson National Wildlife Refuge (NWR), together with the San Luis and Merced NWRs, is part of the San Luis NWR complex. These refuges, along with the Los Banos and Volta Wildlife Areas and about 160 private duck clubs in Grassland Water District, comprise one of the most important waterfowl wintering areas in the Pacific states.

Kesterson NWR is located adjacent to Grassland Water District. The refuge comprises approximately 5,900 acres, about 1,280 acres of which form Kesterson Reservoir. Kesterson Reservoir was constructed to serve as a regulatory reservoir to regulate flows in the San Luis Drain prior to their discharge into the Delta. The San Luis Drain north of Kesterson was never constructed, however; consequently, Kesterson became the terminus of the drain. From 1972 to 1978, flows into Kesterson Resrvoir were mainly surface water flows from local sources and the Delta-Mendota Canal. By 1978 water deliveries included some subsurface agricultural drainage, and beginning in 1981 flows into the reservoir consisted almost entirely of subsurface agricultural drainage. From 1981 to 1985 the reservoir received approximately 8,000 acre-feet per year of this drainage from Westlands Water District.

The use of Kesterson Reservoir for the disposal of agricultural drainage resulted in an anomaly. The facility is part of an NWR of central importance to Pacific Flyway waterfowl. Approximately 130 species of migratory and resident birds have been recorded at Kesterson NWR, including ducks, geese, swans, herons, egrets, raptors, shorebirds, and a large variety of songbirds. Kesterson Reservoir is, in fact, attractive to waterfowl, and it provides habitat for both the roosting and nesting of birds. The reservoir is also highly contaminated with selenium, a naturally occurring trace element, which has resulted in an abnormally high incidence of reproductive failures, embryo and chick deformities and mortalities of waterfowl at the facility.

Irrigated agriculture is the primary land use in the western San Joaquin Valley, and portions of the valley contain highly seleniferous soils. Selenium contamination has been observed, for example, in Grassland Water District, which until recently used tile drainage flows as a supplemental water supply for the duck clubs in the district.

Although the selenium pollution at Kesterson is not an isolated situation, as this Board emphasized in Order No. WQ 85-1, the problems at Kesterson are fairly unique and stem from the location, construction, and management of this facility. The inclusion of the reservoir in an NWR has clearly resulted in an increased hazard to waterfowl. The ponds at Kesterson were constructed in a manner which resulted in substantial seepage into the ground water and with inadequate capacity to handle certain wet weather events. The ponds served as evaporation basins, allowing constituents in the drainage water to concentrate to levels hazardous to waterfowl and other wildlife. In addition, the site was managed to encourage waterfowl use, with, for example, vegetation attractive to waterfowl.

Based upon the record before the Board, the Board concludes in this Order that the Bureau's proposed plan for a phased approach to cleanup of Kesterson cannot be approved. The first two phases of the phased approach entail the in-place management of the contaminated soils, sediments, and vegetation at Kesterson Reservoir. Through this approach, the Bureau is attempting "to harness the natural processes at Kesterson to control safely the effects of residual contamination, particularly selenium, without having to resort to the costly process of excavating and segregating the contaminated materials in a new facility."[1] The cleanup strategy is based upon the research efforts of scientists from the University of California at Berkeley (UCB) and Lawrence Berkeley Laboratory (LBL), whose work the Bureau has funded.

The Board concludes that, although the Bureau's research results are promising, the Bureau has failed to demonstrate that the first two cleanup phases meet regulatory requirements for approval. Significant scientific uncertainties and a continuing threat to waterfowl and other wildlife are associated with these two phases. In particular, the Board notes that Kesterson Reservoir would continue to provide habitat for some waterfowl and wildlife species under these cleanup phases, although the habitat would be degraded.

Although the Board does not approve the Bureau's proposed in-place management strategy for use at Kesterson, the Board recognizes the critical importance of the UCB and LBL research program. Selenium is a regional problem in the western San Joaquin Valley, and the UCB/LBL research results hold promise as a potential, viable solution. The Bureau is commended for funding this innovative program and is strongly encouraged to continue it.

The Board again stresses that Kesterson is a factually unique situation. The Board's disapproval of the Bureau's proposed management strategy should not be considered a precedent since the Board's decision is based upon the unusual circumstances at the site. In particular, this Order should not be construed as a disapproval of the in-place management strategy for other places in the San Joaquin Valley.

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[1] Reporter's Transcript of State Board Hearing on January 26 and 27, 1987, on Closure Plan, Vol. 1 (R.T. 1), p. 4.

II. BACKGROUND

The historical background of the development of the San Luis Drain and Kesterson Reservoir and the water quality problems which resulted from the discharge of tile drainage from the drain into Kesterson Reservoir were discussed in some detail in Order No. WQ 85-1. That discussion will not be repeated here.

After adoption of Order No. WQ 85-1, the Secretary of the Department of the Interior announced on March 15, 1985, that Kesterson Reservoir would be closed. To facilitate closure, the Department of the Interior entered into an agreement with Westlands Water District on April 3, 1985, which required that discharges of tile drainage to the San Luis Drain be phased out entirely by June 30, 1986. In accordance with the agreement, Westlands Water District plugged its collector drain system and terminated all discharges to the San Luis Drain during the week of June 9, 1986.

In order to meet the requirements of State Board Order No. WQ 85-1, the Bureau undertook a program to identify alternatives for cleanup and land use of Kesterson Reservoir. In April 1986 the Bureau released a Draft Environmental Impact Statement, pursuant to the National Environmental Policy Act, 42 U.S.C. §§ 4321 et seq., to address the environmental impacts of various cleanup scenarios for Kesterson Reservoir and the San Luis Drain. In October 1986 the Bureau released a Final Environmental Impact Statement in which the Bureau proposed a phased approach for cleanup of Kesterson Reservoir. The phased approach is embodied in the Bureau's Closure Plan.

As an integral part of the Bureau's effort to identify and analyze cleanup alternatives for Kesterson, the Bureau began funding the research program proposed by scientists from UCB and LBL in August 1985. In the early stages of the program, field hydrological and geochemical measurements, as well as ecological investigations, were emphasized. More recently, the program has been expanded to include more extensive field and laboratory work. The results of these investigations form the basis, in part, for the Bureau's Closure Plan.

III. DESCRIPTION OF PHASED APPROACH

The Bureau's phased approach for cleanup of Kesterson Reservoir consists of three elements. These are: the Flexible Response Plan (FRP); the Immobilization Plan (IP); and the Onsite Disposal Plan (ODP). Under the phased approach, the FRP would be implemented first. If the FRP failed to meet post-closure management goals proposed by the Bureau for Kesterson Reservoir, and tests showed that the IP is feasible, the IP would be implemented as Phase 2. If both the FRP and IP failed to meet the cleanup goals, the third phase, the ODP, would be implemented. Extensive monitoring programs, as well as nuisance abatement actions, are also a part of each of the plans.

The Bureau proposes to implement the FRP in March 1987 if the latest research results indicate that the FRP may achieve post-closure management goals within one to five years. These goals are selenium concentration goals for both water and food chain items. The water quality goals are:

(1) Surface water: 2-5 parts per billion (ppb) (filtered total selenium)

(2) Ground water: 10 ppb (filtered total selenium)

The goals for food chain items are:

(1) Waterfowl and mammal food chain items: 3 parts per million (ppm) (dry weight)

(2) Fish food chain items: 5 ppm (dry weight)

Under the Bureau's phased approach, annual decisions on whether to continue with a particular phase would be made by the Bureau, in consultation with the United States Fish and Wildlife Service (FWS), and reviewed by the State Board. The Bureau has developed interim food chain goals to guide the annual decisionmaking process. Monitoring data would be reviewed to determine whether observed declines in selenium concentrations were consistent with the interim goals. The interim goals are preliminary and could be adjusted upward or downward. Annual decisions would also be based upon whether certain subjective water quality protection goals were being achieved. Specifically, the Bureau would consider whether there was any impairment or significant threat of impairment of beneficial uses of offsite ground water or of adjacent surface water.

The Bureau has indicated that it is proposing the phased approach because it has the potential for substantial cost savings if subsequent phases are not implemented, leaves other cleanup options open, allows consideration of the latest research results, and provides measures for assuring environmental protection during implementation of the phased approach. The potential for cost savings is illustrated by the following table prepared by the Bureau, which lists the estimated costs of the three phases.

COST SUMMARY

PLAN	ITEM	FIRST YEAR COSTS	ANNUAL COSTS YEARS 2-5
		-- (in thousands of dollars) --	
FRP	Capital Costs	$ 400	$ ---
	Monitoring and Operating Costs	1,980	1,080
	Total Cost	$ 2,380	$1,080
IP	Capital Costs	$ 5,590	$ ---
	Monitoring and Operating Costs	1,910	1,080
	Total Cost	$ 7,500	$1,080
ODP	Capital Costs	$23,065	$ ---
	Monitoring and Operating Costs	1,555	588
	Total Cost	$24,620	$ 588

The environmental protection measures include an extensive monitoring program and nuisance abatement measures. The goal of the nuisance abatement program is to reduce exposure of fish and wildlife resources to residual contamination at Kesterson Reservoir during the cleanup process and to compensate for any continuing exposure that is not avoided. The nuisance abatement measures consist of: hazing, development of an alternative 130-acre habitat, funding of an FWS study of the San Joaquin kit fox, an endangered species under the Endangered Species Act, 16 U.S.C. §§ 1531 et seq., and provision of a temporary supply of Central Valley Project (CVP) water to offsite wetlands.

A. FRP

Under the FRP the southern ponds of Kesterson Reservoir, Ponds 1 through 8, would be flooded with water. The water supply for the ponds would be shallow ground water under and immediately adjacent to the reservoir, provided by ten wells drilled by the Bureau along the eastern edge of the reservoir, between the southern edge of Pond 7 and the northern edge of Pond 12. The selenium concentration of the extracted ground water is presently less than 2 ppb. The Bureau also plans to construct at least 12 additional wells along the western edge of Ponds 3 through 7.

Concurrently with implementation of the FRP, Pond 4 would be used to evaluate the effectiveness of the IP. Pond 4 would be kept at a deeper water depth than that maintained under the FRP, and vegetation would be wet harvested to test the effectiveness of harvesting emergent vegetation while the pond is flooded.

The northern ponds of Kesterson Reservoir, Ponds 9 through 12, would be treated differently than the southern ponds. The four northern ponds would not have applied water. The rationale for the difference in treatment is that the northern ponds generally have lower selenium concentrations in the soils and sediments than the southern ponds. In addition, the soils of the northern ponds are more permeable and, therefore, are less likely to hold applied water than the southern ponds.

The dry areas of the northern ponds (approximately 237 acres) would be treated differently than the areas of the northern ponds which are seasonally wet due to rainfall and rising ground water. The seasonally wet areas comprise approximately 178 acres. The dry areas would be tilled to minimize vegetation and reduce wildlife habitat, if testing indicates that tilling will reduce food chain contamination and will not result in ground water contamination. The seasonally wet areas would be monitored. If food chain contamination persisted, contingency actions might be implemented.

The Bureau has indicated that the FRP is based upon several major assumptions, including:

(1) Selenium can be contained in the southern pond sediments by keeping them wet;

(2) Low selenium water applied to the southern ponds will control selenium transport in surface water; and

(3) Wildlife exposure to contamination in the northern ponds can be reduced through vegetation management.

B. IP

The IP is essentially a minor extension of the FRP, with additional management procedures to minimize selenium mobility and reduce wildlife exposure. These procedures include raising water elevations and wet harvesting emergent vegetation in the southern ponds. Tilling would be continued in the northern ponds if tilling has been shown to be effective. If not, vegetation in the dry areas would be harvested and taken to an approved disposal site. If post-closure management goals are not being achieved in the wet areas of the northern ponds, these areas would be tilled, vegetation would be harvested and taken to an approved disposal site, or the wet areas would be filled.

C. ODP

The ODP would be implemented no later than 1992 if neither the FRP nor the IP were successful in achieving post-closure management goals. The ODP is expected to take about one year to implement. Under the ODP all above ground vegetation would be harvested from Ponds 1 through 12. Harvesting procedures would remove essentially all of the above ground vegetation and that portion of the detritus which is easily separable from the underlying soil. The upper six inches of soil from all of Ponds 1 through 4 and selected areas of Ponds 5 through 12 would be excavated in order to remove sediments with a selenium concentration greater than 4 ppm. After excavation, the entire site would be sampled and additional excavation conducted, as necessary, in order to reduce the mean selenium concentration in the excavated area to below 3 ppm. Following excavation and confirmatory sampling, the entire site would be tilled to a depth of 12 inches.

A landfill for containment of the excavated materials would be located in the western half of Pond 3. The estimated volume of excavated materials for disposal in the landfill is 650,000 cubic yards. The landfill would be constructed with a double liner, consisting of a low permeability soil liner and a synthetic membrane liner. Landfill features also include a surface drainage system sized to handle the 1,000-year, 24-hour precipitation event, a leachate collection system, a gas collection system, and a series of twelve monitoring wells.

Under the ODP no attempt would be made by the Bureau to restore Kesterson Reservoir to a managed wetland through provision of a water supply. It is anticipated that about 780 acres of the reservoir would become upland habitat, about 45 acres of Pond 3 would be used for the onsite landfill and buffer area, and about 420 acres would become seasonal wetlands. The 1280 acres of Kesterson Reservoir would also be removed from the Kesterson National Wildlife Refuge because of the incompatibility of a landfill with wildlife refuge uses.

IV. ANALYSIS OF CLOSURE PLAN

A. Legal Requirements

The Porter-Cologne Water Quality Control Act, Water Code Sections 13000 et seq., requires the State Board, in order "[t]o ensure adequate protection of water quality and statewide uniformity in the siting, operation, and closure of waste disposal sites", to classify wastes according to the risk of water quality impairment and classify types of disposal sites according to the level of protection provided for water quality. Water C. § 13172. Consistent with these classifications each Regional Water Quality Control Board (Regional Board) must review and classify proposed or currently operating waste disposal sites. Id. § 13226.

The State Board has adopted regulations implementing these statutory provisions in Subchapter 15, Chapter 3 of Title 23 of the California Administrative Code (Subchapter 15 regulations). The Subchapter 15 regulations, governing waste disposal to land, include waste and site classification provisions and waste management requirements for waste treatment, storage, or disposal in landfills, surface impoundments, waste piles, and land treatment facilities. The Subchapter 15 regulations also include provisions for the closure and post-closure maintenance of these waste management units.

In Order No. WQ 85-1 the State Board concluded that Kesterson Reservoir is a surface impoundment subject to the requirements of the Board's Subchapter 15 regulations. In Cleanup and Abatement Order No. 85-1 the Bureau was directed to take appropriate action to comply with the Subchapter 15 regulations. Appropriate cleanup strategies, specified in the order, included: closure of the site in accordance with the closure requirements of Subchapter 15, upgrading the site to meet applicable Subchapter 15 requirements, or any other acceptable alternative. The Bureau was also directed to achieve full compliance with Subchapter 15 requirements no later than three years from the date of the order, that is, by February 5, 1988, unless compliance by an earlier date was required under the Toxic Pits Cleanup Act of 1984 (Toxic Pits Act), Health and Safety Code Sections 25208 et seq.

The Subchapter 15 requirements for closure of a surface impoundment are contained in Article 8. Specifically, Section 2582 of Article 8 requires the removal of all free liquids from the impoundment. Following liquid removal, the regulation describes two alternatives for closure:

(a) removal of all remaining residual wastes and contaminated natural geologic material from the unit and disposal at an approved disposal site. If removal of all remaining contaminated geologic material is infeasible, the site must be covered and capped in accordance with Subchapter 15 requirements for a landfill.

(b) closure of the unit as a landfill, provided that the unit meets the Subchapter 15 siting and construction standards for a landfill.

The Bureau is seeking State Board approval, under Section 2510 of Subchapter 15, of an alternative to the requirements of Section 2582 for the Closure Plan as a whole and for each phase of the Closure Plan. Section 2510(b) allows the State and Regional Boards to consider alternatives to the construction or prescriptive standards contained in Subchapter 15 if the following conditions are met:

(1) the standard is "not feasible", and

(2) there is a specific engineered alternative that is both consistent with the performance goal addressed by the particular standard and affords equivalent protection against water quality impairment.

A standard is "not feasible" when a discharger demonstrates that compliance with the standard is:

(1) unreasonably and unnecessarily burdensome and will cost substantially more than alternatives which meet the criteria in subsection 2., above; or

(2) is impractical and will not promote attainment of applicable performance standards.

In assessing feasibility, the State and Regional Boards are directed to consider all relevant technical and economic factors, including, but not limited to, present and projected costs of compliance, potential costs for remedial action in the event that waste or leachate is released to the environment, and the extent of ground water resources which could be affected.

The Bureau is also seeking approval, specifically for the ODP, of an alternative to the siting requirements, contained in Section 2530 of Subchapter 15, for landfills. Section 2530 requires five feet of separation between the wastes in a landfill and the highest anticipated elevation of the underlying ground water.

A discharger who is proposing an alternative containment method under Section 2510 bears the burden of proving that the alternative meets the criteria of Section 2510. A decision by the State Board or a Regional Board to approve an alternative must be supported by the weight of the evidence. See Water Code Section 13330(b) and C.C.P. Section 1094.5(c). The weight of the evidence is considered to be synonymous with a preponderance of the evidence. Chamberlain v. Ventura County Civil Service Com'n, 69 Cal.App.3d 362, 368, 138 Cal.Rptr. 155, 158 (1977).

The administrative record of the adoption of Subchapter 15 provides guidance on the goals of the subchapter and, in particular, the goals of

Section 2582. A major goal of Subchapter 15 is "the prevention of [waste] discharges to ground water".[2] Among the critical factors supporting the discharge prevention goal are the facts that "[g]roundwater is vulnerable to contamination, hard to monitor, difficult to clean up, and virtually non-renewable once seriously contaminated" and that "[w]hen wastes have escaped containment features, they are generally beyond control".[3] It is recognized that "[w]ater which cannot be used for domestic supply may still have potential uses which could be impaired by pollutants leaking from the waste management unit".[4] In order to implement the discharge prevention goal, the regulations focus on "provid[ing] adequate containment at waste management units".[5] The regulations discourage leakage rates and pollutant attenuation as waste management strategies.[6]

The administrative record of the adoption of Subchapter 15 indicates that the performance goal of Section 2582, in keeping with the overall discharge prevention goal of the subchapter, is to prevent the escape of residual wastes from a surface impoundment upon closure.[7] The escape of

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2 Statement of Reasons for Subchapter 15 (SOR), Response to Comments, Discharge Prevention Goal, p. 2.

3 Id., p. 3.

4 Id.

5 SOR, Response to Comments, Performance Standards versus Construction Standards, p. 9.

6 SOR, Response to Comments, Discharge Prevention Goal, pp. 4-5.

7 SOR, p. 8.8.

wastes "pose[s] a threat to water quality, either through degradation of underlying ground water or through surface runoff of waste from the unit".[8]

The administrative record of Subchapter 15 also provides insight into the proper interpretation of Section 2510. The record indicates that Section 2510 provides "a mechanism for regional board approval of alternative containment systems which will provide an equivalent level of containment for wastes discharged to land".[9] "Appropriate environmental protection is meant to be based on adequate containment."[10]

The Bureau apparently takes the position that the Board must approve an alternative to a standard in Subchapter 15, under Section 2510, if the alternative will not cause "pollution". This is not the criteria. The guiding factors under Section 2510(b)(2) are consistency with the performance goal of the standard in question and the degree of equivalency of water quality protection provided by the alternative.

B. Waste Classification

The Bureau has assumed in its Closure Plan that the contaminated soils, sediments, and vegetation at Kesterson Reservoir will be classified as either a nonhazardous or a designated waste. The classification of the wastes at Kesterson Reservoir determines the degree of water quality protection required under the State Board's Subchapter 15 regulations. The higher the waste classification, the more stringent are the controls imposed by Subchapter 15. The regulations classify wastes into three categories: hazardous, designated,

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8 Id., p. 8.7.

9 SOR, p. 1.2.

10 SOR, Response to Comments, Performance Standards versus Construction Standards, p. 9.

and nonhazardous. Art. 2, Ch. 3, Subchapter 15. Hazardous wastes are wastes which are required to be managed under the Department of Health Services' hazardous waste management regulations, contained in Chapter 30, Division 4 of Title 22 of the California Administrative Code. 23 Cal.Admin.Code § 2521. Designated wastes fall into two categories:

1. hazardous wastes which have been granted a variance by the Department of Health Services (DOHS); and

2. nonhazardous wastes which consist of or contain pollutants which, under ambient environmental conditions at the waste management unit, could be released at concentrations in excess of applicable water quality objectives, or which could cause degradation of waters of the state. Id. § 2522. The remaining wastes, generally speaking, fall into the nonhazardous waste category. See id. § 2523.

When Order No. WQ 85-1 was written, the State Board was primarily concerned with the water quality impacts of the wastewater in Kesterson Reservoir. Constituents in the wastewater exceeded a number of established criteria and standards in effect at the time of adoption of the order. These constituents included: selenium, mercury, nickel, hexavalent chromium, zinc, copper, cadmium, and boron. Based upon the complex chemical characteristics of the wastewater and its observed effects on wildlife, the Board found that the wastewater was a hazardous waste for purposes of regulation under both the Subchapter 15 regulations and the Toxic Pits Act.

Kesterson Reservoir is not currently storing any agricultural drain water. When Westlands Water District terminated drainage flows to the San Luis Drain, the remaining drainage water stored at Kesterson either evaporated or seeped into the ground water. The remaining contaminated materials of concern at Kesterson consist of vegetation, soils and sediments. Therefore, the issue of waste classification must address only these materials.

Of the constituents of concern previously identified by the State Board in Order No. WQ 85-1, the only element in the sediments of Kesterson Reservoir which exceeds background or San Joaquin Valley soil levels is selenium,[11] and selenium has been identified by the Bureau as the principal contaminant of concern at Kesterson. Selenium concentrations in Kesterson Reservoir wildlife, including invertebrates, birds, fish, and small mammals, are significantly elevated compared to control areas.[12] Further, elevated selenium levels have been linked to the deaths and deformities of birds using the reservoir.[13]

The Bureau has conducted extensive sampling of sediments and vegetation at Kesterson Reservoir. These samples have been analyzed in accordance with DOHS criteria, contained in Article 11, Chapter 30 of the DOHS hazardous waste management regulations, for identification of hazardous wastes. Section 66699 of Article 11 provides that a concentration of selenium is hazardous if it exceeds its soluble threshold limit concentration (STLC) or its total threshold limit concentration (TTLC) values. These values are:

	STLC ppm	TTLC ppm (wet weight)
Selenium	1	100

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11 Risk Assessment, Kesterson Program (November 1986) (Risk Assessment), pp. 2-9 and 2-10, Table 2-5.

12 See Risk Assessment, *id.*, pp.2-9 through 2-16; Environmental Impact Statement, Vol. II, Kesterson Program (April 1986) (EIS-II), pp. 3-9 through 3-10, 4G-1 through 4G-3, 4H-7, 4H-12 through 4H-22.

13 E.g., EIS-II, pp. 4H-17 through 4H-18.

Article 11 also provides that a waste is hazardous if it has an acute aquatic 96-hour LC_{50} less than 500 milligrams per liter (mg/l). 22 Cal.Admin.Code § 66696(a)(4).

Of over 600 soil samples collected at Kesterson at the 0- to 6-inch depth, excluding the surficial organic layer, none exceeded the TTLC level.[14] Extractable selenium levels in the sediments also did not exceed the STLC of 1 ppm.[15] Bioassay studies similarly showed that the Kesterson sediments were not hazardous under the acute aquatic toxicity criteria of DOHS.[16]

The results of the Bureau's sampling program indicate that selenium has concentrated in Kesterson Reservoir within the top few inches of sediments and, particularly, in the organic muck or detritus.[17] To illustrate, the average concentration of selenium in 40 detritus samples collected from Ponds 1 through 5 in January 1986 was 165 ppm (dry weight) and 23 ppm (wet weight).[18] The average for all 0- to 2-inch depth samples collected in December 1984 was 55 ppm (dry weight), and one of the 12 samples was greater than 100 ppm.[19] By contrast, the overall average concentration of all 0- to 6-inch soil samples

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14 Id., p. 3-7.

15 Id.

16 Id., p. 4A-5.

17 Id., p. 3-7.

18 Id.

19 Id.

collected at Kesterson Reservoir in May and November 1985 was 5 ppm.[20] The depth distribution of selenium in Kesterson soils is also illustrated by analysis of a six-inch core sample taken by LBL personnel.[21] The results of the analysis are as follows:

POND	Sample Depth (inches)	Total Selenium ppm (dry weight)
5	0-1	204.0
	1-2	48.0
	2-3	9.6
	3-4	2.4
	4-5	1.6
	5-6	1.0

The analysis results indicate that the top inch of this sample would exceed the TTLC level for hazardous waste.[22]

With respect to the areal distribution of selenium, Bureau sampling has shown that, although portions of all of the ponds have selenium soil concentrations higher than 5 ppm, the highest concentrations are found in the southern ponds.[23] These ponds received the greatest amount of agricultural drainage.

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20 Id., p. 4A-4.

21 Progress Report (20 August - 30 November, 1985), Earth Sciences Division, LBL, LBID 1101 (Progress Report 1), pp. 4-18 through 4-22.

22 Hazardous waste criteria are based on dry weight. In the Bureau's Waste Classification Report, Kesterson Program (September 1986) (Waste Classification Report), the Bureau indicated that the average moisture content of Kesterson Reservoir sediments is 40 percent. Dry weight concentrations can be converted to wet weight by multiplying the dry weight concentration by one minus the fraction moisture content, or, in this case, by 0.6. Consequently, 204 ppm (dry weight) would be 122.4 ppm on a wet weight basis.

23 EIS-II, p. 4A-5 and Fig. 4-4. See also Closure Plan, Fig. IV-1; Environmental Impact Statement, Kesterson Program, Volume 1 (October 1986) (EIS-I), Fig. 2-5.

In Kesterson vegetation, only the selenium and boron concentrations are significantly higher than background.[24] Little data is available regarding the toxic effects of boron in wildlife species, and there is no existing evidence linking boron to observed effects on wildlife at Kesterson Reservoir.[25] Therefore, the discussion of waste classification of the Kesterson vegetation will center on selenium.

Selenium concentrations in 351 samples of stem and leaf material from dominant plant species throughout Kesterson Reservoir ranged from 2 to 161 ppm.[26] Two percent of the stem and leaf samples exceeded the TTLC level of 100 ppm for classification of the material as hazardous.[27] These concentrations occurred in Ponds 1, 3, 5, 6, 8, and 11.[28] Concentrations of selenium in below-ground plant parts, roots and rhizome material from dominant plant species throughout the reservoir, ranged from 4 to 330 ppm.[29] The Bureau estimates that about 23 percent of the 10,000 metric tons of below ground biomass has a selenium concentration greater than the TTLC level of 100 ppm on a wet weight basis.[30] Extractable selenium concentrations in all vegetation were below the STLC of 1 ppm.[31]

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24 EIS-II, pp. 3-9, 4F-14 through 4F-16.

25 Risk Assessment, p. 2-20.

26 EIS-II, p. 4F-14. These samples were on a "dried" weight basis, with the moisture content ranging from 7 to 48 percent. Id., p. 4F-15.

27 Id.

28 Id.

29 Id.

30 Waste Classification Report, Section 2, p. 1.

31 Id.

Based upon the results of its monitoring data, the Bureau has concluded that the contaminated soils, sediments and vegetation at Kesterson Reservoir can be classified as either a nonhazardous or a designated waste. By letter October 9, 1986, the Bureau transmitted a Waste Classification Report (September 1986) to DOHS, requesting the concurrence of DOHS in the Bureau's determination that the contaminated materials at Kesterson can be classified as nonhazardous. Alternatively, the Bureau requested a variance from DOHS' hazardous waste management regulations if DOHS should determine that the materials are hazardous. The Bureau has not, as yet, received a response from DOHS to its submittal.

For purposes of this order, we conclude that the contaminated materials at Kesterson Reservoir are, at a minimum, a designated waste. Portions of the vegetation sampled by the Bureau, in fact, exceed hazardous waste levels, and selenium levels in the surficial sediments and detritus are quite high. As we will explain later in this Order, there are a number of processes which can result in the remobilization and recycling of selenium at Kesterson. These processes can result in the further degradation of ground water. Additionally, the release of selenium can degrade the surface waters of Kesterson, which is a wetland area.[32] The release of selenium into surface waters threatens the beneficial use of the site as critical waterfowl habitat.

The Board also concludes that it is appropriate to defer to DOHS with respect to the issue of whether the contaminated soils and vegetation should be

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32 Order No. WQ 85-1, pp. 12 & 19; EIS-II, pp. 4I-6.

considered hazardous. As discussed previously, the Board's Subchapter 15 regulations define hazardous wastes as wastes which are required to be managed as hazardous wastes under the hazardous waste management regulations of DOHS. This issue is presently pending before DOHS, and we will defer to that agency for a resolution of the issue.

C. <u>Compliance With Time Schedule in Cleanup and Abatement Order No. 85-1</u>

Cleanup and Abatement Order No. 85-1 required the Bureau to take appropriate action to comply with Subchapter 15 requirements regarding seepage and the threat of future surface discharges from Kesterson Reservoir. The Bureau was required to submit a plan to the State Board, "including a detailed time schedule for implementation of the measures to achieve full compliance with" these provisions, and to "achieve full compliance ... no later than three years from the date of [Cleanup and Abatement Order No. 85-1], unless compliance by an earlier date is required under the Toxic Pits Act."

The Bureau has taken the position that Cleanup and Abatement Order No. 85-1 can be interpreted to mean that February 5, 1988, represents the date by which implementation of a cleanup plan must be initiated, and not the date by which cleanup must be completed. The Bureau has also indicated that, under the FRP, final closure will be completed by February 5, 1988, although it may take up to five years for the plan to achieve the Bureau's ultimate post-closure management goals.

The Bureau's interpretation of Cleanup and Abatement Order No. 85-1 is not supported by the record of the Kesterson proceedings. The record indicates that State Board staff originally proposed a two-year deadline for full compliance with the pertinent provisions of the cleanup and abatement order.[33] After hearing testimony from the Bureau on January 8, 1985, the Board extended the compliance deadline to three years.[34] It is also apparent from the record that the Bureau understood that cleanup of the site was to be achieved no later than February 5, 1988.[35] In addition, the language of Cleanup and Abatement Order No. 85-1 clearly requires "full compliance", not the initiation of compliance.

The Bureau cites the definition of "closure" in Subchapter 15 in support of its position that cleanup need only be initiated, not completed, by February 5, 1988. We do not agree.

The term "closure" is defined in the regulations to mean the "termination of waste discharges at a waste management unit and operations necessary to prepare the closed unit for post-closure maintenance". 23 Cal.Admin.Code § 2601. In Cleanup and Abatement Order No. 85-1 the Board directed the Bureau to achieve full compliance with Subchapter 15 requirements regarding seepage and surface discharge, by closure or any other appropriate cleanup strategy, within three years. The Board intended that the Bureau complete "closure", as defined in Subchapter 15 if this option were selected, within three years. That is, by February 5, 1988, the Bureau was to have terminated waste discharges to the site and completed operations necessary to prepare the site for post-closure maintenance. At the end of the three-year

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33 Reporter's Transcript, State Board hearing on January 8, 1985, on petition of Robert James Claus, p. 5.

34 _Id_. at 80-81, 114-117, 310-311.

35 See fn. 34 _supra_.

period, the Bureau should be prepared to commence post-closure maintenance activities. These would typically include monitoring and routine maintenance of drainage and containment features.

Under the Bureau's phased approach the ODP could be implemented as late as 1992, if the FRP and IP are unsuccessful in achieving the Bureau's post-closure management goals. This schedule does not comply with the compliance deadline in Cleanup and Abatement Order No. 85-1. On the other hand, the Bureau estimates that landfill construction under the ODP could be completed in about a year. Consequently, if the ODP were implemented immediately, the Bureau could achieve substantial compliance with the time schedule in Cleanup and Abatement Order No. 85-1.

D. Section 2510 Requests

As discussed previously in Section IV.A. of this Order, the Bureau has made two requests, pursuant to § 2510 of Subchapter 15, for approval of alternatives to the requirements of the subchapter. The first request is for approval of an alternative to the Section 2582 requirements for closure of a surface impoundment. This request applies to the Closure Plan as a whole and to each phase of the plan. The second request is specific to the ODP and seeks approval of an alternative to the Section 2530 requirement for five feet of separation between the wastes in a landfill and ground water.

The Bureau's Section 2510 requests are the key issues raised in the Closure Plan. The discussion which follows will address each of these requests.

1. Section 2582

In order for the State Board to approve an alternative to the closure requirements of Section 2582, the discharger must demonstrate that the requirements of Section 2582 are infeasible. In addition, the discharger must demonstrate that the alternative both: (1) is consistent with Section 2582's performance goal of preventing the escape of residual wastes from the containment unit and (2) affords equivalent protection against water quality impairment as that afforded by either complete removal of all residual wastes or closure of the entire surface impoundment as a landfill.

The Bureau contends that the closure options provided in Section 2582 are infeasible because they are unreasonably and unnecessarily burdensome and will cost substantially more than its phased approach. The Bureau estimates that the costs of the first closure option, removal of all residual wastes and contaminated soil, would be at least $250 million. This estimate is based on the cost of excavating all of Kesterson to a depth of two feet and hauling it to an offsite Class II landfill. Alternatively, the Bureau estimates that the costs of removal of the top six inches of soil and closure of the site as a landfill would be in excess of $165 million.

The remaining closure option of Section 2582 is closure of the surface impoundment as a landfill. This option is available only if the impoundment meets the Subchapter 15 construction and siting criteria for a landfill. Assuming that the contaminated soils and vegetation at Kesterson Reservoir are a designated waste, the site, in its present condition, does not meet the Subchapter 15 requirements for a Class II landfill. For example, the ponds do not meet the liner requirements of Subchapter 15. See 23 Cal.Admin.Code § 2532(b) and Fig. 4.2. Therefore, this option is not available to the Bureau.

Under the Bureau's phased approach, the FRP, or the FRP as modified by the IP, may be the only plan which is implemented at Kesterson. The ODP is a contingency measure which the Bureau proposes to implement only if the FRP and IP are unsuccessful in achieving post-closure management goals. Under the phased approach the FRP, or the FRP and IP, may be in effect up to five years or indefinitely, depending on whether or not the ODP is implemented. Because the FRP, or the FRP as modified by the IP, may be the only cleanup phase implemented by the Bureau under its phased approach, we will first examine the FRP and IP to determine whether they meet the criteria of Section 2510.

a. FRP and IP

(1) Selenium Chemistry

In order to evaluate the different phases of the Bureau's Closure Plan, it is necessary to briefly review the major features of selenium chemistry.[36] The environmental behavior and fate of selenium is complex because of the number of oxidation states in which selenium may exist, and because of the interactive effects of chemical and biological factors. The principal features of selenium chemistry that affect its movement and toxicity are associated with changes in its oxidation state and the resulting differences in chemical properties. Each oxidation state is briefly discussed below:

> Selenate (+6 oxidation state) is soluble and readily accessible to plants. It is the principal selenium species that was leached from irrigated soils in Westlands Water District and delivered to Kesterson Reservoir via the San Luis Drain.
>
> Selenite (+4 oxidation state) is less soluble than selenate. It readily adsorbs to clays and iron oxides, thereby decreasing its availability to plants. As a dissolved species, it is subject to plant uptake.

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36 See discussion in EIS-II, p. 4A-11.

Elemental selenium (0 oxidation state) is insoluble and inaccessible to plants. It can be formed by chemical and microbial reduction of selenate or selenite.

Selenide (-2 oxidation state) may occur in aquatic systems in both organic and inorganic forms. Inorganic selenide can be formed by chemical and microbial reduction of selenate, selenite, and elemental selenium. It is insoluble and inaccessible to plants. Aquatic organisms absorb and reduce inorganic selenium to selenide before synthesizing it into a variety of organic selenide compounds.

(2) Scientific Basis for FRP and IP

The basis for the FRP and IP is the observation that most of the selenium that was applied to Kesterson Reservoir in the past, as a result of the discharge of tile drainage flows from Westlands Water District, has been chemically reduced and deposited in the upper few inches of sediments and decaying organic material.[37] The selenium species present in the surficial sediment layer include adsorbed selenite, elemental selenium, and selenide.[38] LBL has hypothesized that the principal mechanism which removed selenium from the surface water is the reduction of selenate, the dominant species in the drainwater, by bacterial action in the bottom sediments to elemental selenium, selenide, and adsorbed selenite.[39] These species are generally insoluble and inaccessible to plants. Under this hypothesis, as long as reducing conditions are maintained in the bottom sediments, through the provision of a water supply and the promotion of bacterial activity, the selenium in the sediments should

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37 Closure Plan, p. II-1.

38 Risk Assessment, p. 3-3.

39 EIS-II, p. 4D-24; see Progress Report 1, p. 4-10; Fourth Progress Report (October, 1986 through December, 1986), Earth Science Division, LBL, LBID 1250 (Progress Report 4), pp. 76-80.

remain immobilized.[40] The maintenance of the these conditions is the management strategy proposed by the Bureau under the FRP and IP for the southern ponds, Ponds 1 through 8, of Kesterson Reservoir.

No attempt would be made, however, under the FRP and IP to immobilize the selenium in the sediments in the northern ponds.[41] Rather, the dry areas of the northern ponds would be tilled to reduce vegetative growth and cover for wildlife, if tilling is shown to be effective. The seasonally wet areas of the northern ponds would be monitored for food chain and wildlife contamination. The rationale for the different management strategy for the northern ponds is that these ponds generally have lower selenium concentrations in the soils and sediments. In addition, these ponds are more permeable and, therefore, less likely to hold applied water.

Implementation of the FRP and IP will have potential impacts on ground and surface quality and on the beneficial uses of these waters. The following discussion will evaluate these impacts.

(3) Ground water Impacts

The United States Geological Survey (USGS) has divided the regional ground water aquifer system in the Kesterson area into three zones: a lower water-bearing zone below the Corcoran Clay, an upper water-bearing zone above the Corcoran Clay, and a shallow water bearing zone in the surficial

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40 See EIS-II, pp. 3-24 and 4D-24.

41 See Closure Plan, pp. II-7 through II-9; R.T. 1, pp. 47-48, 82-83, 88-89; Reporter's Transcript of State Board Hearing on January 26 and 27, 1987, on Closure Plan, Vol. II (R.T. 2), pp. 21-23; EIS-II, 4A-12, 4D-16, 4F-9, 4H-26 through 4H-27.

deposits.[42] The depth to the Corcoran Clay ranges from about 180 feet beneath Kesterson Reservoir to 600 feet beneath the southern end of the San Luis Drain.[43] In the Kesterson area, the shallow water bearing zone is continuous with the upper zone; no apparent barrier to ground water flow exists between these two zones.

The beneficial uses of the ground water aquifer system are identified in the Water Quality Control Plan Report, Central Valley Region (Basin Plan). They are: irrigation, stock watering, and municipal and domestic water supply.[44] The lower water-bearing zone beneath the Concoran Clay is, in fact, of high quality and serves as the major source of drinking water for the San Joaquin Valley. The upper zone in the Kesterson area, however, is of marginal quality and has limited beneficial uses.

The regional ground water gradient around Kesterson Reservoir is northeastward toward Salt Slough and the San Joaquin River.[45] Salt Slough is located roughly 7,100 feet and the San Joaquin River is 2.3 miles to the northeast of Kesterson Reservoir. A local high ground water condition exists, however, under Kesterson Reservoir.[46] Water seeping from the reservoir moves vertically into the shallow aquifer and laterally in all directions.[47] The lateral flow to the west discharges toward Mud Slough, which is located on the

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[42] EIS-II, p. 4D-1.

[43] Id., p. 4A-1; EIS-I, p. 4-1.

[44] Basin Plan, p. I-2-5.

[45] R.T. 1, p. 55; EIS-II, p. 4D-1.

[46] R.T. 1, p. 56.

[47] EIS-II, p. 4D-2.

western border of Kesterson.[48] Flow to the south is inhibited by the regional flow, and flow to the north and east intermixes with the native ground water and moves with the regional flow toward Salt Slough and the San Joaquin River.[49] The estimated average ground water velocity away from Kesterson Reservoir toward Salt Slough is 50 to 1,000 feet per year. [50]

Pre-construction monitoring data on Kesterson Reservoir indicates that the shallow aquifer levels fluctuated seasonally from roughly 8 feet below to 1 to 2 feet above land surface.[51] Seasonal highs typically occurred in December and January, and seasonal lows in later summer or early fall.[52]

In assessing the ground water impacts of the Bureau's Closure Plan, it is necessary to separate impacts due to previous operating conditions at Kesterson Reservoir from potential future problems. Existing ground water contamination due to past operational practices will be discussed first.

Approximately, 8,000 acre-feet per year of drainage water was discharged into Kesterson Reservoir from 1981 to 1985, and approximately one-half of this flow annually seeped into the underlying ground water. The rate of seepage and fluid velocity of drainage water entering the ground water was

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48 Id.

49 Id.

50 Id.

51 Id.

52 Id.

greatest along the eastern edge of the reservoir.[53] Water entering the ground water along the eastern edge flows toward Salt Slough and the San Joaquin River at an estimated pore velocity of about 150 feet per year.[54]

The past application of wastewater to Kesterson Reservoir has resulted in a significant rise in the concentrations of boron, copper, molybdenum, nickel, selenium, and TDS in the shallow ground water.[55] Of these constituents, selenium appears to have the greatest potential for adversely impacting beneficial uses. Bureau sampling data in 1985 indicated that selenium was the only constituent in the shallow ground water which consistently exceeded applicable criteria at Kesterson Reservoir, but not at control areas.[56] For example, the average selenium concentration exceeded the primary drinking water standard established by the Environmental Protection Agency for the protection of human health (10 ppb).[57] Six samples exceeded the maximum criterion for the protection of freshwater aquatic life, and several exceeded the 24-hour average for the protection of freshwater aquatic life.[58]

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53 R.T. 1, p. 57.

54 Id.

55 See Risk Assessment, p. 2-7, Table 2-4 and pp. 2-1 through 2-9.

56 EIS-II, p. 4D-8.

57 Id.

58 Id.

There is abundant data on the vertical extent of seepage from the Kesterson ponds.[59] Boron has been detected in high concentrations in the ground water underlying Kesterson Reservoir and is considered an indicator of seepage of pond water.[60] Boron concentrations in the ground water under Kesterson of 10 to 20 ppm indicate that drainage water has migrated to an average depth of 60 feet, but varies from less than 20 feet to about 130 feet.[61] Thus, pond waters have infiltrated deep into the upper aquifer.[62]

The vertical penetration of selenium, however, does not correlate with the maximum depth to which the pond water has moved. The average concentration of selenium, unlike boron, in the ground water is significantly lower than the average concentration of selenium in the previously applied drainage water. This suggests that most of the selenium has been removed from the drainage water, probably by chemical or biological processes.[63] Although selenium concentrations in the shallow ground water underlying Kesterson have reached over 300 ppb in two areas, the Bureau estimates that the average selenium concentration in the uppermost stratum, defined as the clay layer underlying the reservoir ranging up to 20 feet in thickness, is 18 ppb.[64] Below this interval, the average concentration is

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59 R.T. 1, p. 57.

60 R.T. 1, pp. 57-58, see Risk Assessment, p. 2-7, Table 2-4.

61 R.T. 1, pp. 57 & 188-189; Progress Report (December, 1985 through June, 1986), Earth Sciences Division, LBL, LBID-1188 (Progress Report 2), p. 50.

62 Progress Report 1, p. 5-27.

63 Risk Assessment, p. 2-8. Concentrations of selenium in the drainage water averaged 300 ppb.

64 EIS-I, pp. 5-53, 5-60.

estimated to be 6 ppb.[65] In certain locations, selenium has migrated to depths of about 50 feet.[66]

Selenium ground water concentrations significantly higher than 10 ppb have been observed in two distinct areas beneath the Kesterson ponds.[67] In one area, under Pond 12, concentrations as high as 350 ppb were observed in early 1985. These concentrations have consistently diminished with time and are currently below 10 ppb.[68]

The second, more extensive area, is centered along the San Luis Drain adjacent to Pond 2, the southern portion of Pond 5, and the northern portion of Pond 1.[69] The maximum measured selenium concentration has been 250 ppb at the western edge of Pond 2;[70] and the maximum depth is approximately 50 feet.[71] Selenium concentrations in several wells in this area showed significant increases in early 1985, and with some variability, have remained high since then.[72]

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65 Id.

66 R.T. 1, p. 75; Progress Report 2, p. 50.

67 R.T. 1, pp. 75-75; EIS-II, pp. 3-8 and 4D-10.

68 R.T. 1, p. 74.

69 Id., p. 75.

70 Id. The EIS-I indicates that a concentration of 310 ppb was measured along the western edge of Pond 2, EIS-I, Fig. 4-12.

71 R.T. 1, p. 75. The second LBL progress report indicates that the major portion of the selenium plume has migrated downward to a depth of approximately 50 feet with a selenium stringer of 18 ppb at approximately 80 feet. Progress Report 2, p. 50 and Fig. 2-7.

72 R.T. 1, p. 75.

Scientists from LBL have concluded that high nitrate levels, together with high infiltration rates, explain the high selenium concentrations in the ground water underlying the southeast portion of Kesterson Reservoir.[73] Pond 2 was the historical entry point for drainwater and had the highest nitrate concentrations. The selenium ground water plume is also centered under Pond 2. The LBL scientists hypothesize that the high nitrate concentrations in the wastewater created oxidizing conditions in the sediments, resulting in the release of selenium. Alternative explanations include a lack of reducing bacteria in some soils and the presence of permeable sand lenses in the area.[74] The latter explanation is probably the cause of the small plume under Pond 12.[75]

An additional factor controlling the movement of selenium is the chemical nature of the ground water itself. The ground water underlying Kesterson in the Pond 2 area is oxidizing,[76] rather than reducing.[77] Elevated concentrations of selenium have not been detected in the ground water under Kesterson where the ground water is reducing. Selenium is not necessarily present, however, where the ground water is oxidizing. In fact, little is known about the chemical behavior of selenium in the ground water below the superficial layer of reducing mud at Kesterson.[78] Consequently, it

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73 R.T. 1, p. 28, 30-31; Progress Report 4, pp. 66-76.

74 Progress Report 4, p. 76; see R.T. 1, pp. 140-141, 184.

75 R.T. 1, pp. 74 and 184; EIS-II, p. 3-8.

76 An example of ground water that is oxidizing is ground water containing dissolved oxygen.

77 R.T. 1, pp. 78-82; see Progress Report 2, pp. 49-58.

78 Progress Report 4, p. 76; see R.T. 1, pp. 58 and 84.

is not possible, at the present time, to accurately predict the movement of selenium in the ground water.[79]

The extent of lateral migration of the selenium plume in the ground water in the southeastern portion of Kesterson is currently undefined due to the lack of existing monitoring wells.[80] Elevated selenium levels have been detected in off-site shallow wells immediately adjacent to the San Luis Drain along Ponds 1 and 5.[81] The maximum selenium concentration detected thus far in these offsite wells has been 37 ppb at a depth of 11 feet.[82] The elevated level in this well, adjacent to Pond 1, may be due to past leakage from the San Luis Drain rather than infiltration from Pond 1.[83]

Nevertheless, the Bureau and LBL scientists have concluded that there is a potential for offsite migration of selenium from Kesterson in the east central portion of Pond 5, the northcentral portion of Pond 2, and near the intersection of the San Luis Drain and Ponds 1 and 2.[84] This conclusion is based upon the regional ground water gradient and the oxidizing nature of the ground water in these areas.

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79 See id.

80 R.T. 1, pp. 57 and 178-179; Progress Report 2, p. 50.

81 R.T. 1, p. 76. The EIS indicates that selenium in concentrations of 10 ppb or greater has been detected in off-site shallow ground water monitoring wells along the eastern edge of Ponds 1, 5 and 7. EIS-I, p. 2-24, Fig. 2-3; EIS-II, Fig. 4-12.

82 R.T. 1, p. 76.

83 Id., pp. 77, 182-183.

84 R.T. 1, pp. 75-80; Closure Plan, II-13 through II-14; Third Progress Report (July, 1986 through September, 1986), Earth Sciences Division, LBL, LBID 1213 (Progress Report 3), pp. 20-21.

As discussed previously, the Basin Plan identifies the beneficial uses of the ground water under Kesterson as irrigation, stock watering, and municipal and domestic water supply. While the deep aquifer below the Corcoran Clay is of high quality, the shallow aquifer has historically been of marginal quality. The total dissolved solids levels have averaged approximately 4,000 ppm and trace metal concentrations in the shallow aquifer have been comparatively high.[85] Although the shallow aquifer is of poor quality, a USGS well survey located 22 wells within a two-mile radius of Kesterson Reservoir which are constructed above the Corcoran Clay.[86] An additional 16 wells penetrated below the Corcoran Clay and were constructed with a gravel pack or tapped aquifers above and below the Corcoran Clay.[87] The Bureau conducted a similar well survey in 1984.[88] The Bureau located about 30 wells, which are used for irrigation, stock watering, or domestic uses.[89] Little data on well depths, however, has been provided. The Bureau concluded, based upon this survey, that, in general, downgradient wells are not used for drinking water purposes.[90]

The land to the east of Kesterson is owned by Freitas Brothers Land and Cattle Company. One of the wells on the Freitas property is an

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85 R.T. 1, p. 64; see Risk Assessment, p. 2.7, Table 2-4.

86 EIS-I, p. 5-207.

87 Id.

88 EIS-II, p. 4D-3, Table 4-20 and Fig. 4-11.

89 See EIS-II, Table 4-20. The domestic uses do not necessarily include drinking water.

90 See EIS-II, p. 4D-3.

irrigation well and is apparently constructed above the Corcoran Clay at a depth of about 70 feet.[91] This well appears to be in the path of the regional ground water gradient and could potentialy be impacted by seepage from the Kesterson ponds.[92]

The seepage that is presently being detected in the shallow ground water underlying Kesterson is the result of the past discharge of agricultural drainage flows with high selenium concentrations. Under the FRP and IP the Bureau proposes to flood the southern ponds with low-selenium ground water, which would also be low in nitrates. Scientists from LBL predict that reducing conditions likely would be reestablished in Pond 2 with the application of a water supply low in selenium and nitrates, and that the selenium leak would subside.[93] Of central importance is the issue of whether leaching of selenium from the sediments in the southern ponds would occur under the FRP and the IP. The LBL scientists have been conducting laboratory leaching experiments on sediment cores to characterize selenium mobility in sediments.[94] The results indicate that low concentrations of selenium can be leached from the sediments.[95] The data, however, lend support to the assumption of low selenium mobility in the southern ponds under sustained wet conditions.

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91 R.T. 1, p. 185.

92 See letters dated January 13 and 30, 1987, from Mr. and Mrs. Frank Freitas to Sheila Vassey, with attached correspondence; Closure Plan, pp. II-13 through II-14; R.T. 1, pp. 177-183.

93 R.T. 1, pp. 29-31.

94 See Progress Report 2, p. 24; Progress Report 3, pp. 13-15; Progress Report 4, pp. 37-51.

95 See _id_.

The wetting of previously dry pond bottom sediments has been identified by LBL scientists as a potential secondary source of selenium contamination of the ground water.[96] The scientists have been conducting a large scale reflooding test in Pond 1 to determine the effects on selenium mobility of drying and wetting the Kesterson ponds.[97] Preliminary data from this experiment has shown a significant remobilization of selenium in the immediate vicinity of the saturated sediments.[98] Dissolved selenium concentrations in the top several feet of the bottom sediments were as high as 2,000 ppb.[99] With one and one-half months of data, the scientists have not as yet seen extensive mobilization of selenium in the shallow ground water.[100] They have observed traces of selenium in the 10- to 12-foot level in the ground water.[101] In addition, one 8 foot well had concentrations in excess of 150 ppb, and one 12 foot well had a concentration of 75 ppb.[102] The extent to which the remobilized selenium will seep into the groundwater is

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96 R.T. 1, p. 82.

97 Id., p. 83; see Progress Report 4, pp. 1-22.

98 Id.

99 R.T. 2, pp. 21-22. Maximum observed selenium levels at the 0.5 foot level were in the range of 4000 to 5000 ppb. Progress Report 4, p. 3. See also LBL memorandum, dated February 26, 1987 to Susan Hoffman from Harold Wollenberg.

100 R.T. 1, pp. 135-136; see Progress Report 4, p. 2.

101 R.T. 2, p. 22.

102 Id.

unknown at the present time.[103] Initial surface water concentrations of selenium in the Pond 1 experiment ranged from 20 to 200 ppb, with an average value of 44 ppb. Surface water samples now have an average selenium concentration of 19 ppb.[104]

The implications of the Pond 1 experiment are twofold. First, significant remobilization of selenium in the sediments of the southern ponds will occur when these ponds are initially flooded under the FRP.[105] The extent to which this remobilized selenium will seep into the groundwater is unknown. Selenium levels in the surface waters of the southern ponds, as a result of remobilization, likely will be above acceptable levels. Secondly, selenium mobilization will occur in the northern ponds, which would not be maintained in a flooded condition and which would be subject to successive wetting and drying.[106] While the relative selenium loads in the northern ponds are low as compared to the southern ponds, selenium concentrations in surface waters in the seasonally wet northern ponds, which would be resaturated as a result of rainfall or rising ground water, could reach unacceptably high levels.[107] The extent to which the remobilized selenium in the northern ponds would pose a threat to the upper ground water aquifer is uncertain.

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103 Progress Report 4, p. 2; see R.T. 2, p. 23; LBL memorandum, dated February 26, 1987, fn. 99 supra.

104 LBL memorandum, dated February 26, 1987, fn. 99 supra.

105 Progress Report 4, p. 22; see R.T. 1, p. 82.

106 See R.T. 2, p. 21; R.T. 1, p. 82; EIS-I, p. 5-199.

107 See R.T. 2, pp. 23-24.

An additional area of uncertainty is the length of time that the management strategies under the FRP and IP would have to be continued. The LBL scientists have indicated that it is not possible to predict when the processes intended to keep selenium immobilized in the southern ponds could be discontinued, although they speculate that it would probably be necessary to keep these ponds flooded for at least a decade.[108] The flux of selenium from the sediments in the southern ponds is expected to diminish over time, with the release of soluble selenium from the sediments to the shallow ground water and the release of a gaseous form, dimethylselenide, to the atmosphere.[109] Substantial amounts of selenium would be transferred to ground and surface waters in the northern ponds as a result of remobilization of selenium when these areas are wetted from rainfall or rising ground water.[110] Therefore, LBL scientists predict that the selenium inventory in the northern ponds will decrease over time.

In sum, two observations can be made regarding the potential ground water impacts of the FRP and IP. First, the experiments conducted to date clearly establish that selenium in the sediments in both the southern and northern ponds will leach into the shallow ground water. Second, the attenuation factor for selenium migration through the soil column is very large. The latter conclusion is based upon the small quantity of selenium present in the ground water relative to the total amount discharged at Kesterson Reservoir. Both the extent of selenium leaching from the sediments

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108 See Supplemental Statement by Oleh Weres, Ph.D., Staff Scientist, LBL, (Supplemental Statement) p. 5; R.T. 1, pp. 92-93.

109 Supplemental Statement, pp. 2-3.

110 Id., pp. 5-6.

under the FRP and IP and the impacts of leaching on the ground water are extremely difficult, if not impossible, to predict at present. The length of time that the management strategies under the FRP and IP would have to be maintained also cannot be predicted. Consequently, it must be concluded that there are significant uncertainties with respect to the potential ground water impacts of the Bureau's proposed strategy.

(4) Surface Water Impacts

Kesterson Reservoir is a wetlands.[111] It is designated in the Basin Plan as a critical habitat because "it is essential to the well-being, protection or conservation of the fish and wildlife resources of the state". As this Board found in Order No. WQ 85-1, the Kesterson area is designated as a critical habitat because it is a wetlands area, essential to waterfowl and water-dependent wildlife.

The Bureau has proposed post-closure management goals, for water quality and food chain items, for wildlife protection. The Bureau has been candid, however, about the continuing scientific uncertainty regarding whether the FRP and IP will be successful in achieving these ultimate wildlife protection goals.[112] In addition, the Bureau has acknowledged that the first two phases of the Closure Plan entail significant, unavoidable risks to wildlife which cannot be mitigated.[113] These risks are primarily the continued risk of contamination of vegetation and wildlife as a result of the uptake of selenium from the soils and sediments into the food chain.

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111 See fn. 32, supra.

112 See, e.g., R.T. 1, p. 19; Closing Legal Memorandum, Department of the Interior's (DOI) Post-Hearing Submission, p. 2.

113 See, e.g., EIS-I, pp. ii, viii, ix, 3-1 through 3-22; EIS-11, p. 4H-39.

Scientists from LBL have been conducting field experiments at Pond 5 of Kesterson Reservoir to measure changes in selenium concentrations in water and the biota when high-selenium drainwater is replaced by low-selenium ground water.[114] The experiments are intended to assess the feasibility of the FRP and IP in attaining the Bureau's post-closure management goals. In the late spring of 1986 a triangular one-acre enclosure was built in Pond 5. The enclosure, Pond 5E, was flooded with low-selenium water, and various media were sampled. Within 20 days, the selenium concentration in water in the enclosure fell from 65 ppb to less than 20 ppb.[115] Concentrations below 10 ppb were reached in 62 days. Levels continued to fall slowly and fluctuate for the next 100 days. Selenium water levels in January 1987 were at 3 ppb.[116] Over the same period, selenium levels in the tissue of a giant algae, Nitella, fell from approximately 63 ppm to 15 ppm, a 76 percent decline.[117] Simultaneously, the selenium concentration in aufwuchs, a microscopic community supported by the Nitella, fell from 68 ppm to 28 ppm, a 59 percent decline.[118] It should be noted, however, that the initial steep decline of selenium content in the

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114 See Progress Report 4, pp. 85-93; R.T. 1, pp. 42-48; Supplemental Scientific Statements from University of California at Berkeley, Sanitary Engineering and Environmental Health Research Laboratory and LBL, March 9, 1987 (Supplemental Scientific Statements), Part I.

115 See Progress Report 4, p. 93, Fig. 3-2.

116 DOI Exhibit 7, State Board hearing on January 26 and 27, 1987, on Closure Plan.

117 See DOI, Exhibit 9, State Board Hearing on January 26 and 27, 1987 on Closure Plan.

118 See id.

submerged vegetation flattened out after approximately 60 days.[119] Selenium concentrations in insects from the community occupying the Nitella beds also experienced a decline during the period from May to December.[120] Selenium levels in mosquitofish from Pond 5E declined from 114 to 67 ppm between May and October, but the levels did not change during the period from October through December.[121] Dramatic decreases of selenium in cattails from Pond 5E were also noted. The roots and rhizomes (the tuber-like structures fed upon by muskrats and geese) of the cattails, in particular, declined in selenium content to less than 3 ppm, a level below one of the Bureau's cleanup goals.[122]

The results of the Pond 5E experiment for all species provide support for the overall concept that a gradual reduction in selenium content in the biota is possible when low selenium water is added to the Kesterson pond habitat. With the possible exception of the roots and rhizomes of cattails, however, the Pond 5E results do not provide sufficient information to determine what the selenium levels in the biota will ultimately be when the levels stop declining.[123] It is, therefore, unclear whether these levels will be below

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119 See id.; Supplemental Scientific Statements, fn. 114, supra, Part I, p. 2.

120 Supplemental Scientific Statements, fn. 114, supra, Part I, pp. 3-4.

121 Id., p. 4.

122 Id., pp. 4-5.

123 See R.T. 1, pp. 51-52, 145-148; R.T. 2, pp. 8, 71-73.

the Bureau's ultimate food chain contamination goals. The length of time it will take to achieve the food chain contamination goals is also uncertain.[124]

Concurrently with the Pond 5E experiment, the Bureau has been measuring changes in selenium concentrations in water and the biota in Pond 5 itself. The flow of high selenium drainwater into Pond 5 was halted in June 1986; however, a brief pulse of seleniferous water entered the pond in August 1986. As a result, selenium content in Pond 5 water declined from approximately 240 ppb in December 1985 to 28 ppb in July 1986 and then rose to 312 ppb in August 1986. Selenium levels in Pond 5 water are currently about 13 ppb.[125]

The results of the Pond 5 biota monitoring are confusing in several respects. First, during the period from March through June 1986, when selenium concentrations in the water were declining, distinctly high selenium concentrations were observed for all species tested in Pond 5.[126] This selenium peak remains unexplained. Secondly, since the cessation of drain flows, the concentrations of selenium in the various plants organisms sampled from Pond 5 have, in general, either remained static or risen.[127] The LBL scientists believe that this result can be explained by the pulse of seleniferous water which entered Pond 5 in August 1986. This explanation may be correct; however, it should be noted that the high concentrations of

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124 See R.T. 1, pp. 146-148; R.T. 2, pp. 71-73.

125 Supplemental Scientific Statements, fn. 114, supra, Part I, Appendix, Table 1.

126 See id. Figs. 1 and 2.

127 See id.

selenium currently observed in vegetation in Pond 5 are higher than those observed in November and December 1985, after Pond 5 had received four years of tile drainage flows. A second possible explanation is that a mechanism is operating in Pond 5 to mobilize selenium which is not occurring in Pond 5E. It is also possible that the concentration rises in Pond 5 are an aberration, which will be corrected over time. Until this occurs, however, the Pond 5E results are suspect.

The Pond 5E experiment also does not address the question of the potential impact of selenium contaminated sediments on the benthic community.[128] Benthic organisms are bottom dwelling organisms which can directly ingest selenium in sediments into their body tissues. Benthic organisms are important food organisms for some waterfowl. Researchers at LBL have identified the benthic food pathway as a potential pathway for selenium cycling and biological mobilization, particularly in the few shallow ponds at Kesterson which dry up early in most years.[129] An example of such a pathway would be via unidentified amorphous detritus to soldierfly and cranefly larvae, which would then be potential prey for shore birds.[130] Researchers at LBL predict that the benthic food pathway will not be a major concern, however, because their sampling has revealed few benthic organisms at Kesterson.[131]

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128 The Pond 5 and 5E analyses do not include data on selenium levels in benthic invertebrates.

129 See Progress Report 2, pp. 80-81.

130 Progress Report 2, p. 81.

131 R.T. 1, pp. 141-142.

Scientists from the FWS, on the other hand, view the benthic or detrital food pathway as a major concern if the FRP or IP is implemented.[132] They point out that LBL investigations have revealed substantial numbers of benthic organisms, specifically, small chironomids, in certain portions of Pond 5.[133] In addition, gut content analyses by LBL researchers have revealed that several of the invertebrates are feeding on the sediments or detrital material.[134]

In a healthy marsh environment the benthic food pathway would be an important pathway.[135] Kesterson, however, is a stressed environment, and the relatively low number of benthic organisms may be symptomatic of this fact. It is unclear whether a vigorous benthic community would be reestablished under the FRP and IP with the provision of a low-selenium water supply. In any event, FWS scientists predict that the benthic community would change under these circumstances.[136]

An additional area of concern has been the extent to which selenium could be remobilized by emergent vegetation, particularly cattails. Vegetation at Kesterson Reservoir includes emergent and nonemergent marsh

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132 See R.T. 1, pp. 150-154, 158, 159; R.T. 2, pp. 74-75; EIS-I, pp. 3-15 through 3-18.

133 R.T. 1, p. 151. See Progress Report 3, p. 43, Table 3-4, indicating that 2,727 large chironomid and 25,394 small chironomid organisms were sampled on December 12, 1985, in a small, near-shore area of Pond 5.

134 See R.T. 1, p. 151; Progress Report 3, p. 58, Table 3-11; Progress Report 4, pp. 90 and 91, Table 3-1.

135 See R.T. 1, p. 141.

136 R.T. 2, p. 74.

plants and submergent aquatic plants.[137] The emergent vegetation is dominated by dense stands of cattails and, to a lesser extent, alkali bulrush. Emergent vegetation is abundant in Ponds 1 through 5, and relatively small amounts of this vegetative type occur in portions of Ponds 6, 7, and 8. Nonemergent vegetation is dominated by saltgrass, alkali heath, and alkali weed. This type of vegetation is abundant in Ponds 6 through 12, and small amounts occur in Ponds 1 and 5. Submergent aquatic vegetation is dominated in different areas by Nitella, blue-green algae, and wigeon-grass. Nitella is most abundant in large areas of deep water, as in Pond 5.

Cattails and other rooted marsh plants can acquire selenium from both the sediments, via their root system, and directly from water, via their leaf tissues.[138] The selenium levels in rooted plants, consequently, could be expected to respond differently from the levels in nonrooted plants, such as Nitella, when a high-selenium water supply is replaced with a low-selenium supply.[139] Cattails and other marsh plants growing in reduced soils oxidize a layer of soil, called the rhizosphere, around the roots.[140] The Bureau's Final Environmental Impact Statement indicated that the presence of cattail roots at Kesterson could cause the oxidation of selenium in the anaerobic sediments at Kesterson, resulting in the uptake of selenate.[141]

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137 Biological Assessment for Endangered Species: Kesterson Program (August 1986), p. 1-7. See discussion in EIS-II, pp. 4F-1 through 4F-5.

138 Risk Assessment, p. 3-26.

139 See EIS-II, pp. 4F-24 through 4F-25.

140 Id., pp. 4F-10 through 4F-11; R.T. 2, p. 9.

141 EIS-II, p. 4F-11; EIS-I, pp. 5-26, 5-172, 5-183; see R.T. 1, p. 157.

The Bureau concluded in the Final Environmental Impact Statement that the oxidizing power of cattail roots could result in a significant, measurable quantity of sediments being oxidized, although the Bureau also concluded that most of the reduced selenium in the sediments would probably not be oxidized further than elemental selenium.[142]

The uptake of selenium by cattails and other rooted marsh plants could pose a threat to wildlife as a result of direct ingestion[143] or as a result of the release of dimethylselenide. A major form of selenium in plants is selenomethionine.[144] The FWS considers the organic forms of selenium, such as selenomethionine, to be more toxic than selenite or selenate.[145] Selenomethionine is thought to pose the greatest threat to herbivorous waterfowl.[146] Plants are also known to release volatile dimethylselenide, an organic form of selenium, to the atmosphere.[147] This form of selenium is bioavailable and can be used as an energy source for certain plankton and algae.[148] Selenium may be released from plants in

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142 EIS-II, 4F-11; see EIS-I, pp. 5-172, 5-183.

143 See, e.g., EIS-II, p. 4H-25.

144 Risk Assessment, p. 4-4.

145 R.T. 1, p. 160.

146 Risk Assessment, p. 4-4.

147 R.T. 1, p. 138; EIS-II, p. 4F-11. Dimethylselenide has been identified among the decomposition products of vegetation collected at Kesterson. Progress Report 2, p. 70; see R.T. 1, pp. 137-138.

148 R.T. 1, p. 158.

organic forms during dormancy or decay.[149] The Pond 5E experiment indicates that the role of rooted vegetation in the transport of selenium from anoxic sediments to the food chain may be relatively unimportant. A concern remains, however, regarding the Pond 5E cattail results. The cattail samples from Pond 5E were collected during the dormant winter season. Nutrient uptake would be greatest during the spring growing season. Whether selenium uptake will be significant in the spring is presently unknown.

There are other processes which could oxidize the anaerobic sediments of the southern ponds at Kesterson and thereby remobilize selenium. These include physical processes, such as wind or wave action, or other circulation processes, which mix highly oxygenated water with the low-oxygen sediment surface layers.[150] In addition, certain microbes oxidize elemental selenium, a reduced form, to selenite, which is bioavailable.[151] Selenium leaching from the sediments may also occur.

As discussed previously, selenium in the sediments of the northern ponds will not be immobilized. Rather, selenium in these sediments will be oxidized and remobilized, as a result of the periodic wetting and drying of the sediments. When these ponds are saturated, selenium in the pond sediments and surface water will be available for uptake into the biota.[152] Although the relative selenium load in the sediments of these ponds is less

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149 EIS-II, p. 4F-12; see R.T. 1, p. 138; Progress Report 2, p. 70.

150 R.T. 1, p. 157.

151 R.T. 1, p. 139, 157.

152 R.T. 1, p. 136; R.T. 2, pp. 23-25.

than in the southern ponds, significant portions of the sediments of these ponds are above levels of 4 ppm, a level selected by the Bureau as its contaminant level.

The Bureau has proposed a number of management strategies for the northern ponds, including tilling the soil in the dry areas. The Bureau is presently conducting experimentation to assess the feasibility of tilling. No results are available as yet, however.[153]

In sum, there are a number of processes, physical, chemical, and biological, which can remobilize the selenium in the bottom sediments of the southern ponds. The laboratory and field experiments conducted by LBL are promising and support the feasibility of the immobilization theory in the southern ponds. Significant concerns remain, however, regarding the importance of the benthic food pathway, Given the limited scope and short duration of the LBL experimentation, we conclude that there is insufficient information at the present time to adequately assess the feasibility of the Bureau's proposed management strategy under the FRP and IP.

We have concluded, like the Bureau, that there are continuing risks to wildlife under the FRP and IP, principally the threat of continuing contamination of the food chain. In order to evaluate these risks, the wildlife impacts caused by Kesterson will be briefly reviewed. Avian deformities and mortalities have been well documented at the site since 1983. Selenium levels in the biota, including vegetation, fish, invertebrates, birds, and small mammals, are all significantly elevated compared to control areas. Selenium levels in a number of small mammals sampled from Kesterson in 1984,

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153 R.T. 2, pp. 18-19.

for example, were 10 to 1,000 times higher than the control area, and reproductive problems were noted for several of the mammals sampled.[154]

The almost total nesting failure of the tricolored blackbird, a candidate endangered species, in 1986 illustrates some of the wildlife impacts which have occurred at Kesterson Reservoir. Last year a colony of about 47,000 breeding adults attempted to nest in the cattail stands of Ponds 2 and 5 at the reservoir.[155] This total represents more than half the San Joaquin Valley population and approximately one-third of the global population. Only about 100 fledglings were observed throughout the colony, and it is estimated that about 82,000 eggs and chicks were lost. Preliminary FWS data suggest that the cause of this mortality was due to acute selenium toxicosis from eating contaminated insects.

Because the rate at which selenium levels in the food chain at Kesterson will decline is uncertain, it is difficult to accurately assess the continuing risks to wildlife under the FRP and IP. Bureau consultants have attempted to make this assessment by developing a risk assessment model, using a "Monte Carlo" simulation technique.[156] The model was used to estimate the probability distribution of predictions of selenium concentration in the diets of key species at Kesterson Reservoir. The model has several critical limitations, including an assumption of steady state conditions, and the model results cannot be used to make quantitative estimates of the impacts of cleanup

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[154] Risk Assessment, p. 2-16.

[155] See discussion in Risk Assessment, pp. 3-7 through 3-10 and Biological Assessment, pp. 3-23 through 3-30.

[156] See Risk Assessment.

alternatives.[157] The model has some utility in providing a comparison of cleanup alternatives. The model estimates that, under the FRP, 35 percent of diet selenium predictions for the tricolored blackbird are below harmful levels of 5 ppm.[158] For the ODP, 60 percent of the predictions are below harmful levels.[159] Similar results were obtained for other bird species at the reservoir. Although it is not possible to quantify the relative risks of the FRP, IP and ODP, the Bureau concedes that, on a qualitative basis, the FRP and IP pose a greater risk to the environment than the ODP.

In recognition of the risks posed by the FRP and IP, the Bureau has proposed measures to assure environmental protection during the implementation of these phases. The measures include monitoring and nuisance abatement actions.

Hazing, one of the nuisance abatement measures, was initiated by the FWS in September 1984.[160] Under the hazing program four FWS employees use various explosive and other devices to haze birds during daylight hours.[161] The hazing program has generally been effective in eliminating most diurnal use of Kesterson by waterfowl such as mallards, which are typically hunted.[162] It has not, however, deterred some nesting efforts by

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157 Id. at S-2; R.T. 1, pp. 106-107.

158 See Risk Assessment, Fig. 5-7.

159 See id.

160 R.T. 1, p. 111.

161 R.T. 1, pp. 111, 171, 172.

162 EIS-II, p. 4H-7; see R.T. 1, pp. 111-112.

ducks, which has resulted in embryonic deformities.[163] And, hazing has largely been ineffective in affecting the behavior of herons, egrets, coots, songbirds such as the tricolored blackbird, raptors, and small mammals.[164] Despite the hazing program, Kesterson Reservoir is still heavily used by many wildlife species.[165]

As an additional nuisance abatement measure the Bureau has proposed to improve a 130-acre habitat in the eastern portion of the Kesterson National Wildlife Refuge in order to provide alternative habitat for the tricolored blackbird.[166] The Bureau hopes that the tricolored blackbirds would be lured away from the contaminated areas of Ponds 2 and 5 to the alternative habitat. It is difficult to be as sanguine as the Bureau about this prospect, however.

Tricolored blackbirds nest colonially in the vicinity of fresh water, especially in marshy areas with heavy growths of cattails and tules.[167] This type of environment is provided in Ponds 2 and 5 of Kesterson.[168] It is not yet available in the 130-acre alternative habitat. Water supplies are currently being developed in order to allow the future

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163 R.T. 1, p. 112.

164 R.T. 1, pp. 112, 172-173, 176; EIS-II, pp. 4H-7 through 4H-10, 4H-26.

165 See id.

166 R.T. 1, p. 113; Closure Plan, p. V-1.

167 R.T. 1, pp. 167-168.

168 See EIS-II, p. 4H-9.

impoundment of water in this area.[169] In addition, estimates range from one year to several growing seasons for the old-growth cattail stands in the eastern portion of the refuge to have sufficient growth for nesting and roosting by the tricolored blackbirds.[170] Assuming that the alternative habit were already developed, however, it is highly questionable whether the birds could be lured away to this new habitat given the facts that hazing has been ineffective in deterring the nesting and roosting activities of these birds and that habitat is presently available in the Kesterson ponds. In any event, if the alternative habitat were developed, it would not accommodate the numbers of birds which attempted to nest at Kesterson in 1986.[171]

A third nuisance abatement measure proposed by the Bureau is the provision of an interim supply of from 8,000 to 12,000 acre-feet of CVP water to appropriate offsite wetlands. Given the general ineffectiveness of hazing for a variety of bird species and the fact that Kesterson, in its present condition, provides waterfowl habitat, albeit contaminated, it is again questionable whether the additional water supply will lure birds away from Kesterson.

Finally, the Bureau is proposing to fund a four-year research study by the FWS of local San Joaquin kit fox populations. The kit fox, an

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169 See R.T. 1, p. 113, 119-120.

170 See R.T. 1, p. 169; Memorandum dated September 30, 1986, from Project Leader, Endangered Species, FWS, to Chief, Division of Planning and Technical Services, Bureau, (FWS Memorandum) p. 27.

171 R.T. 1, pp. 114, 169.

endangered species, has been observed at Kesterson.[172] It is considered at risk of contamination because studies at Kesterson have indicated that small mammals collected at the margins of the Kesterson ponds are highly contaminated.[173] The small mammals are a potential prey base for the kit fox.[174] While this Board commends the Bureau for the proposed study, the study alone will not alleviate the potential risk to this species.

Under a worst case analysis, wildlife impacts at Kesterson Reservoir over the next five years would be similar to impacts observed at the site in the last two years. Should this occur, the tricolored blackbird, just one of many species at the reservoir, could suffer continued nesting failure. This risk is unacceptable. In addition, it is important to note that the presence of the large flock of birds observed in 1986 was an unexpected occurrence. Similar unexpected events could also happen in the future.[175]

In summary, we conclude that there is insufficient information to adequately assess both the feasibility of the Bureau's proposed management strategy for the southern and northern ponds under the FRP and IP and the potential impacts of these plans on waterfowl and other wildlife. Further, significant potential, unavoidable risks of continuing contamination of wildlife are associated with the FRP and IP.

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172 R.T. 1, p. 115. See discussion in Biological Assessment, pp. 2-1 through 2-12.

173 Biological Assessment, pp. 2-8 through 2-9; see FWS Memo, pp. 10-11.

174 See Risk Assessment, pp. 3-6 through 3-7.

175 See, e.g., R.T. 1, p. 174.

(5) Conclusions

Based on the preceding discussion, the Board concludes that the Bureau has failed to demonstrate that the FRP and the IP meet the criteria specified in Section 2510. While the Bureau's research program is very promising, the Board finds that there is insufficient information to adequately assess the technical feasibility of the FRP and IP. There are significant uncertainties, for example, regarding selenium remobilization processes, impacts of selenium leaching on ground water, and the long-term management implications of this cleanup approach. The FRP and IP, in addition, involve significant risks to wildlife which are not adequately mitigated by the Bureau's proposed nuisance abatement measures. It is apparent that residual wastes, specifically selenium, will escape from Kesterson Reservoir into the ground water, into surface waters and into the biota under this cleanup strategy. It is also clear that leaving the contaminated soils, sediments and vegetation in place will not afford water quality protection equivalent to that provided by removal of all residual wastes or closure of Kesterson as a landfill. Having reached these conclusions, it is unnecessary for the Board to address whether the Section 2582 closure options are infeasible in light of the FRP and IP alternatives proposed by the Bureau.

b. ODP

The ODP, the third phase of the Bureau's cleanup program, represents a more conventional type of waste management approach. Under the ODP, contaminated soils and sediments would be excavated, vegetation would be harvested, and these materials would be placed in an onsite landfill in the western half of Pond 3 at Kesterson.[176] The landfill would be constructed to meet the Subchapter 15 construction standards for a Class II landfill.[177]

The ODP is an alternative to the closure options provided in Section 2582 because the Bureau is not proposing to remove all contaminated materials at the site. Nor is the Bureau proposing to cover and cap the entire site as a landfill. The Bureau estimates that the cost of the latter would be in excess of $165 million.

Under the ODP the Bureau would harvest all above-ground vegetation and excavate six inches of soil from the entire area of Ponds 1 through 4 and from selected areas of the remaining ponds. The Bureau intends to excavate all areas with soil selenium concentrations greater than 4 ppm.

The Bureau selected 4 ppm as the contaminant level for several reasons. This level is considered the maximum safe selenium concentration for animal feed.[178] It is also the level selected by FWS in that agency's modified environmentally preferred alternative for cleanup of Kesterson.[179]

As indicated previously, the risk assessment performed by Bureau consultants concluded that the ODP has a greater potential for success than the FRP, although the ODP is not without risk. The risk assessment model concluded that the ODP had a 65 to 90 percent frequency of below harmful effect

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176 See discussion in Closure Plan, pp. IV-1 through IV-22 and R.T. 1, pp. 94-100.

177 See, *e.g.*, 23 Cal.Admin.Code §§ 2532 and 2540 et seq.

178 EIS-II, p. 4A-22.

179 EIS-I, p. vii.

predictions, as compared to 40 to 65 percent under the FRP.[180] The potential risks under the ODP stem primarily from the fact that some contaminated materials will not be excavated. These materials include soils with selenium concentrations below 4 ppm and below-ground vegetation. The Bureau's rough estimates of the depth distribution of selenium contaminated below-ground vegetation are: 25 percent in the upper 2 inches of soil, 50 percent in the upper 6 inches, 75 percent in the upper 12 inches, and 95 to 100 percent in the upper 24 inches.[181]

We conclude that it is appropriate to approve the concept of the ODP as an alternative to the closure requirements in Section 2582 for the following reasons. Under the ODP the Bureau proposes to remove the great majority of contaminated materials at Kesterson, including the highly contaminated surficial layers of sediments and detritus. The Bureau proposes to conduct an extensive sampling program, after the initial excavation of contaminated materials, in order to ensure that the mean selenium concentration in the sediments of all ponds is below 3 ppm. Bureau sampling indicates that the remaining selenium in the sediments and vegetation is, in general, of low solubility. Because the Bureau is proposing under the ODP to remove the bulk of the contaminated materials at Kesterson, it appears that little residual wastes should escape from the site. Removal of the bulk of the contaminated materials should ensure that impacts on ground and surface water quality are minimal. In particular, removal of the highly seleniferous materials should greatly alleviate the threat to wildlife caused by food chain contamination.

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180 Risk Assessment, p. S-3.

181 Closure Plan, p. IV-1 through IV-2.

Post-closure monitoring of the site will provide additional assurance that wastes are being adequately contained. The monitoring will also provide data on the necessity, if any, for instituting further remedial measures.

The Bureau contends that the closure options provided in Section 2582 are infeasible, based primarily upon cost. In this regard, we note that the costs cited by the Bureau to implement the closure options provided in Section 2582 are substantially more than the projected costs for the ODP. In addition, the Section 2582 closure options would require the hauling of substantial quantities of contaminated materials to an off-site Class II landfill. Whether an appropriate landfill exists within the vicinity of Kesterson, with capacity to handle these materials, is uncertain. Therefore, the Section 2582 closure options appear to be unreasonably and unnecessarily burdensome as compared to the ODP. Further, for the reasons previously explained, the amount of residual waste which could be released to the environment under the ODP should be minimal. Also, the shallow ground water underlying Kesterson is of marginal quality. Consequently, we conclude, for purposes of evaluating the ODP, that the Section 2582 closure options are not feasible, as defined in Section 2510.

c. Closure Plan as a Whole

The Bureau also seeks approval of the Closure Plan as a whole, as an alternative to the closure requirements of Section 2582. The Bureau points out that, under the phased approach, the ODP would ultimately be implemented if monitoring indicated that the FRP or IP were not successful in meeting the Bureau's post-closure management goals.

We conclude that each phase of the Bureau's Closure Plan must be approvable under Section 2510 as an alternative to the closure requirements of

Section 2582. This conclusion must be reached because the Bureau is proposing the ODP only as a contingency measure; the FRP or IP might be the only plans which would be implemented under the phased approach.

Further, assuming that the ODP were ultimately implemented in 1992 because the previous cleanup phases were unsuccessful in meeting cleanup goals, the Board notes that food chain contamination would have persisted for a five-year period. This would be unacceptable.

The Bureau seeks approval of the phased approach because the Bureau has determined that substantial cost savings would result if the latter cleanup phases were not implemented. The Bureau's cost estimates, contained in Section III of this Order, indicate that the FRP costs substantially less than the ODP, for example.

Using the Bureau's cost figures, we have estimated the present costs of various cleanup scenarios. The following table lists these present costs, assuming a six percent interest rate and ongoing projects costs extending for 30 years.

PLAN (years in parenthesis)	PRESENT COST (in thousands of dollars)
FRP (30)	$17,100
IP (30)	$22,200
ODP (30)	$32,600
FRP (5), IP (25)	$21,900
FRP (5), ODP (25)	$30,000
FRP (4), IP (1), ODP (25)	$35,100
IP (5), ODP (25)	$35,200

We have examined the applicable present cost estimates for the IP, ODP, and the combined IP and ODP and have concluded that the Bureau's phased approach appears to provide little cost benefit. If the IP was implemented first and was successful, for example, the Bureau might save approximately $10.4 million compared to implementation of the ODP immediately. If the plan was not successful, however, and the ODP was implemented at the end of five years, the Bureau would lose approximately $2.6 million in comparison to implementing the ODP immediately.

2. Section 2530

In order to construct the landfill proposed in the ODP, the Bureau must also obtain approval for an alternative to the Subchapter 15 siting criteria for a Class II landfill. Section 2530 of Subchapter 15 requires a minimum of five feet of separation between any waste and the highest anticipated elevation of underlying ground water.

The ground elevation in the western half of Pond 3 ranges from 74 to 75 feet mean sea level (MSL).[182] The Bureau proposes to fill the bottom of Pond 3 in the landfill vicinity to a minimum elevation of 76 feet MSL. The recurrence interval for ground water levels to exceed 76 feet MSL in the vicinity of Pond 3 is 25 years.[183]

The Bureau contends that approval of an alternative to the requirements of Section 2530 should be allowed because raising the base of the landfill would cost $3 million and could jeopardize the liners, by increasing the risk of settlement of the landfill base and rupture of the liners. In

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182 Id., p. IV-4.

183 Id.

addition, the Bureau contends that its proposed landfill design affords equivalent water quality protection by the use of two liners.

Subchapter 15 specifies that a site for a Class II landfill must be underlain by natural geologic materials which have a permeability of not more than 1 x 10^{-6} centimeters per second (cm/sec) or the site must have a liner consisting of at least two feet of clay meeting the 1 x 10^{-6} cm/sec permeability criteria. See 23 Cal.Admin.Code §§ 2532(b) and 2542(b) and Fig. 4.2. The Bureau proposes to construct a clay liner for the ODP having a thickness of at least two feet and a permeability less than 1 x 10^{-7} cm/sec. In addition, the Bureau proposes to place a 40 millimeter thick high-density polyethylene synthetic liner over the clay liner. The Bureau's proposed design is significantly better than that required by the Subchapter 15 regulations in that the clay liner will have a permeability ten times "tighter" than that required under the regulations and, in addition, will have a second artificial liner, which is not required under the regulations.

No soils data were provided by the Bureau to support the contention that the addition of five feet of soil beneath the liners could cause serious settlement problems. It may be that the underlying soil properties are relatively uniform and that settlement would, consequently, be essentially uniform. Further, areas with near-surface soils having a high potential for settlement problems could be over-excavated and replaced with good soils.

We conclude, nevertheless, that it is appropriate to approve the Bureau's proposed design as an engineered alternative to the siting requirement in Section 2530. We reach this conclusion based upon the superior design proposed by the Bureau. On balance, the additional cost involved in raising the landfill base does not appear to be warranted.

E. Waste Discharge Requirements

In the preceding discussion, the Board has examined the two major issues raised in the Bureau's Closure Plan, specifically the Bureau's requests for approval of alternatives to Section 2582 and 2530 of Subchapter 15. With the exception of these issues, the Board has not attempted to address the specific provisions of the Bureau's Closure Plan.

Issues which we have not addressed include, for example, the question of whether the Bureau should institute a ground water extraction program at Kesterson. We have also not addressed the selection of indicator parameters and the location and number of points of compliance wells for the ground water monitoring program, pursuant to Article 5 of Subchapter 15.

These, and other specific provisions of the Bureau's Closure Plan, will be addressed when waste discharge requirements for closure of Kesterson are adopted. A time schedule is included in this Order for the adoption of waste discharge requirements by the Central Valley Regional Board and for complete construction of the ODP by the Bureau. Under this schedule the Bureau is allowed 60 days to provide the information specified in Section 2595, 2596, and 2597 of Subchapter 15 or, if the information is already contained in previous Bureau submittals to the Board, to inform the Board of the location of this information in the previous submittals. After this 60-day period, the Central Valley Regional Board will adopt waste discharge requirements within 90 days covering the closure and post-closure maintenance of the site. After the adoption of waste discharge requirements, the Bureau will have one year to fully implement, i.e., to completely construct, an on-site landfill. Because this time schedule will extend the time schedule in Cleanup and Abatement Order No. 85-1 for complete implementation of cleanup, the State Board will amend the cleanup and abatement order accordingly.

F. Public Trust

As mentioned previously, in Order No. WQ 85-1, we found that Kesterson is a wetlands and, therefore, waters of the state. Consistent with this finding, the Natural Resources Defense Council (NRDC) requests the Board to apply the public trust doctrine to Kesterson. Specifically, NRDC asks the Board to require the Bureau "immediately and permanently to provide mitigation for the wetland habitat that has been destroyed by the contamination of Kesterson Reservoir".[184]

Wetlands are accorded special protective status in California. For example, through the passage of Senate Concurrent Resolution 28 on January 1, 1983, the California Legislature indicated its "intent to preserve, protect, restore and enhance California's wetlands and the multiple resources which depend upon them for the benefit of the people of the state." Similarly, with respect to coastal wetlands, the Legislature has declared that "[h]ighest priority shall be given to improving or eliminating discharges that adversely affect ... [w]etlands, estuaries, and other biologically sensitive sites ...." Water C. § 13142.5. On January 9, 1987, the State Fish and Game Commission adopted a Wetlands Resources Policy, stating that "[t]he Commission strongly prefers mitigation which would achieve expansion of wetland acreage and enhancement of wetland habitat values." The Basin Plan provision, previously discussed, which designates the Kesterson area as a critical habitat essential to waterfowl and water-dependent wildlife is consistent with these policies.

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184 Letter, dated January 30, 1987, from Hamilton Candee, NRDC, to W. Don Maughan, (NRDC letter) p. 6.

The Bureau has indicated that, if the ODP is implemented, no active attempt will be made to restore the site to a managed wetlands through provision of a water supply. The Bureau anticipates that about 780 of the 1280 acres at the site would become upland habitat, and about 420 acres would become seasonal wetlands. The Bureau is not currently proposing to provide offsite wetlands to mitigate for the loss of the wetlands under the ODP.

The Bureau has stated that State Board approval of the ODP under Section 2510 would require the destruction of a wetland. We find this proposition untenable. The past discharge of high selenium drainwater has resulted in the contamination of the Kesterson wetlands. When the site is cleaned up, the Bureau has a number of available options for restoring wetland habitat values. These include, at a minimum, restoration of the existing site and purchase of off-site wetlands.

In previous actions, we have approved Regional Board actions which required mitigation for destruction or alteration of wetlands.[185] Under the facts of this case, we also feel that mitigation measures may be appropriate and should be addressed by the Bureau.

In this connection, we note that the Bureau has proposed mitigation measures in conjunction with the FRP and IP but not under the ODP. The need for mitigation measures for the ODP appears to be equally as great as for the FRP and IP, however. Accordingly, the Bureau is directed to provide a report to the Central Valley Regional Board within 60 days which addresses the need for appropriate mitigation measures to compensate for the loss of wetland habitat values at Kesterson. This issue will also be addressed by the Central Valley Regional Board when they adopt waste discharge requirements for the closure and post-closure maintenance of Kesterson.

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185 See, e.g., State Board Orders Nos. WQ 83-6 and 84-9.

G. Toxic Pits Act

As discussed previously, in Order No. WQ 85-1 this Board found that the liquid waste discharged into Kesterson was a hazardous waste and, therefore, that Kesterson was subject to the provisions of the Toxic Pits Act. In particular, the Board concluded that Section 25208.4 of the Toxic Pits Act applied to Kesterson. This section prohibits the discharge of liquid hazardous wastes or hazardous wastes containing free liquids into a surface impoundment after June 30, 1988 if the impoundment is within one-half mile upgradient from a potential drinking water source.

The NRDC urges the Board to insure that the goals of the Toxic Pits Act are met at Kesterson, by insuring "that by June 30, 1988, the Bureau cease storing its selenium-laden wastes at the presently unlined, leaking Kesterson facility".[186] The NRDC notes that the term "discharge" is defined in the Toxic Pits Act to include storage.[187] The argument is made that "much of the constituents at Kesterson are either still being 'stored' at the site, or have leaked into the groundwater below the Reservoir".[188]

The Board finds that this Order, and our previous Kesterson decisions, are consistent with the provisions of the Toxic Pits Act. Section 25208.4 requires, for facilities meeting the conditions of the section, both the termination of liquid hazardous waste discharges and the closure of the surface

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186 NRDC letter, p. 9.

187 See Health and Safety C. § 25208.2(f).

188 NRDC letter, p. 8.

impoundment. In our view, the Bureau has ceased to discharge liquid hazardous wastes at Kesterson. Further, the actions taken by the Bureau and this Board will ensure that the facility is closed as required by Section 25208.4.[189]

H. Basin Plan

Evidence has been introduced into the State Board record on the Bureau's Closure Plan which calls into question the propriety of the beneficial use designations in the Basin Plan for the ground water aquifer underlying Kesterson Reservoir. We note, for example, that although the Basin Plan specifies domestic uses as a beneficial use for the entire aquifer, this may not, in fact, be an existing beneficial use for waters in the upper ground water aquifer. As noted previously, the TDS levels in this aquifer are approximately 4000 ppm.

We will, therefore, direct the Central Valley Regional Board to reconsider the beneficial use designations for the ground water aquifer. It appears that the Regional Board should consider establishing beneficial use designations which distinguish between the upper and lower ground water aquifers.

V. CONCLUSIONS

For the reasons explained above, the State Board concludes as follows:

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189 "Closure" is defined in Section 25208.2(d) of the Toxic Pits Act as "the permanent termination of all hazardous waste discharge operations at a waste management unit and any operations necessary to prepare that waste management unit for postclosure maintenance which are conducted pursuant to ... the regulations adopted by the state board and the department concerning the closure of surface impoundments."

1. The remaining contaminated materials at Kesterson Reservoir, specifically the soils, sediments and vegetation, are, at a minimum, a designated waste for purposes of regulation under Subchapter 15;

2. The Bureau has failed to demonstrate that the FRP and IP meet the criteria of Section 2510(b)(2) as specific engineered alternatives to the requirements of Section 2582(b);

3. The Bureau has demonstrated that the concept of the ODP meets the criteria of Section 2510(b) for approval as an alternative to the requirements of Section 2582(b);

4. The Bureau has failed to demonstrate that the Closure Plan as a whole meets the criteria of Section 2510(b) for approval as a specific engineered alternative to the requirements of Section 2582(b);

5. The Bureau has demonstrated that the ODP meets the criteria of Section 2510(b) for approval as a specific engineered alternative to the requirements of Section 2530(c);

6. Waste discharge requirements will be adopted by the Central Valley Regional Board for the closure and post-closure maintenance of Kesterson Reservoir.

7. In order to provide sufficient time for the adoption of waste discharge requirements by the Central Valley Regional Board, the time schedule contained in Cleanup and Abatement Order No. 85-1 should be amended.

8. The Bureau should submit a report within 60 days of the date of this Order which addresses the need for appropriate mitigation measures to compensate for the loss of wetland habitat values.

9. This Order is consistent with the requirements of the Toxic Pits Act.

10. The Central Valley Regional Board should reexamine the beneficial use designations in the Basin Plan for the ground water aquifer in the Kesterson area.

VI. ORDER

IT IS HEREBY ORDERED that the Bureau's requests for approval of the FRP and IP under Section 2510(b) as specific engineered alternatives to the requirements of Section 2582(b) are hereby denied;

IT IS FURTHER ORDERED that the Bureau's request for approval of the concept of the ODP under Section 2510(b) as a specific engineered alternative to the requirements of Section 2582(b) is hereby approved;

IT IS FURTHER ORDERED that the Bureau's request for approval of the Closure Plan as a whole, under Section 2510(b), as a specific engineered alternative to the requirements of Section 2582(b) is hereby denied;

IT IS FURTHER ORDERED that the Bureau's request for approval of the ODP, under Section 2510(b), as a specific engineered alternative to the requirements of Section 2530(c) is hereby approved;

IT IS FURTHER ORDERED that waste discharge requirements shall be adopted by the Central Valley Regional Board and full implementation of the ODP shall be achieved in accordance with the following time schedule:

1. Within 60 days of the date of this Order, the Bureau shall submit the information specified in Sections 2595, 2596, and 2597 of Subchapter 15 or, if the information is already contained in previous Bureau submittals to the State Board, to inform the Central Valley Regional Board of the location of this information in the previous submittals;

2. After expiration of this 60-day period, the Central Valley Regional Board will adopt waste discharge requirements within 90 days covering the closure and post-closure maintenance of the site;

3. After the adoption of waste discharge requirements, the Bureau shall have one year to fully implement, that is, to completely construct, an on-site landfill.

IT IS FURTHER ORDERED that Cleanup and Abatement Order No. 85-1 is hereby amended in accordance with the provisions of this Order.

IT IS FURTHER ORDERED that the Bureau shall submit a report to the Central Valley Regional Board within 60 days of the date of this Order, which addresses the need for appropriate mitigation measures to compensate for the loss of wetland habitat values at Kesterson.

IT IS FURTHER ORDERED that the Central Valley Regional Board shall reexamine the beneficial use designations in the Basin Plan for the ground water aquifer in the Kesterson area.

VII. CERTIFICATION

The undersigned, Administrative Assistant to the Board, does hereby certify that the foregoing is a full, true, and correct copy of an order duly and regularly adopted at a meeting of the State Water Resources Control Board held on March 19, 1987.

AYE: W.D. Maughan
D.E. Ruiz
E.H. Finster
D. Walsh
E.N. Samaniego

NO: None

ABSENT: None

ABSTAIN: None

Maureen Marche
Administrative Assistant to the Board