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ALTERNATIVE HABITAT PROTOCOL
USFWS
FOR DRAINWATER EVAPORATION BASINS
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INTRODUCTION

The San Joaquin Valley Drainage Program's recommended plan for management of agricultural drainage water in the San Joaquin Valley included the continued use of evaporation basins as a disposal technique predicated on the requirement that the basins would have to be either bird-safe or bird-free (SJVDP 1990:91). That meant the basins would either have to be benign to the birds that are exposed to them (bird-safe), or the exposure of birds would have to be prevented (bird-free). To make evaporation basins bird-safe, concentrations of contaminants would have to be low enough not to pose toxic risks, or the avian food chain would have to be eliminated. So far, no feasible technologies for decontaminating drainage water or biotically sterilizing the drainage water have been identified.

In the SJVDP's recommended plan it was proposed that a bird-free emphasis should be pursued for evaporation basins with greater than 2 ppb waterborne selenium via modifying the design and operation of the basins. The centerpiece of the operational recommendations was a hazing program, that if successful, would substantively contribute to eliminating or reducing avian use of evaporation basins. It was recognized by SJVDP technical staff that the prospects for successful hazing would be significantly enhanced by combining hazing with the provision of safe alternative habitat. As operators of duck clubs can affirm, if safe alternative habitat is available, the hazing effect of hunting soon causes ducks to avoid using hunt club wetlands. The SJVDP's recommended plan also proposed that the ratio of alternative habitat to evaporation basin habitat should be 1:1 (SJVDP 1990:127). The derivation of the 1:1 ratio appears to have been primarily intuitive (L. Puckett, California Department of Fish and Game, pers. comm.). Indeed, the 1:1 ratio makes intuitive sense based on the reasoning that the scarce wetlands in the Valley, including evaporation basins, are packed to capacity with waterbirds. Therefore, to get birds at evaporation basins to relocate, at least an equivalent area of new alternative wetlands would be required. The SJVDP's intuitive ratio was also reasonably consistent with the first attempt to derive an alternative habitat ratio based on explicit scientific reasoning (Bradford et al. 1989). Bradford et al. calculated that the ratio of alternative wetland to evaporation basin area should be 1.33:1 (Bradford et al. 1989; 1991).

By means of a memorandum of understanding (USBR et al. 1991), the U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service (Service), U.S. Soil Conservation Service, U.S. Geological Survey, California Department of Water Resources, California Department of Fish and Game, California Department of Food and Agriculture, and the **STATE WATER RESOURCES CONTROL BOARD** adopted the SJVDP's (1990) recommended plan as "...the principle guide for remedying subsurface agricultural drainage and related problems." Consequently, the SJVDP's 1:1 alternative habitat ratio is established as the presently applicable interagency consensus and should be implemented unless interagency consensus can be reached on a different ratio or protocol. Herein the Service presents a new protocol that we believe provides an improved scientific basis for determining the alternative habitat obligations necessary for continued operation of evaporation basins.

ALTERNATIVE HABITAT PROTOCOL

Experience with intensive hazing at Kesterson Reservoir (e.g., Benson et al. 1993) and research on hazing at evaporation basins (Salmon et al. 1991) revealed a more complex situation than was recognized in the SJVDP's (1990) recommended plan. These studies suggest a situation for which it is unrealistic to suppose that hazing at evaporation basins can exclude all kinds of birds all of the time, even in the presence of alternative habitat. Conceptually, it is more realistic to recognize that hazing, at best, produces a sort of "musical chairs effect" by influencing how often and how long birds occupy the available "habitat chairs" without physically removing any of the chairs. Thus, to differing degrees, all chairs (i.e., wetlands... including evaporation basins) will continue to be utilized. Hazing combined with alternative habitat can DILUTE, BUT NOT ELIMINATE, avian exposure to contaminants at evaporation basins. The determination of alternative habitat obligations, therefore, is actually an optimal dilution problem at a landscape scale of analysis. Accordingly, the primary function of alternative habitat should be to transform (via dilution) an unsafe evaporation-basin-centered local landscape into a safe local landscape.

Here, the Service utilizes a landscape scale analysis to derive a scientifically explainable, and therefore defendable, set of equations that deductively provide solutions to the optimal dilution problem. These equations simultaneously provide a protocol for objectively estimating the alternative habitat obligations appropriate for each evaporation basin. Alternative habitat is envisioned by the Service as year-round wetlands that are located within the "functional landscape" of a target evaporation basin. The functional landscape of an evaporation basin is defined as a limited radius (perhaps ca. 1 km) around a basin within which the presence of alternative habitat, in combination with hazing and other management actions, is very likely to significantly dilute the contaminant exposure of birds attracted to the basin.

DILUTION STANDARD

The initial requirement for solving the dilution problem is to establish a dilution standard (DS). For this protocol the Service conceptually defines the dilution standard as the maximum safe dietary selenium exposure for waterbirds on a long-term basis. This definition of the dilution standard is the definition that requires the least amount of alternative habitat. The Service has compiled an annotated summary of recent scientific literature that is relevant to the task of assigning a numerical value to DS (see the Service's exhibit titled, Dilution Standard Appendix). Based on that scientific literature, a consistent range of about 2 ppm to 4 ppm dietary selenium was identified for threshold responses varying from purely physiological to reproductive lethality. Based on considerations of site-specificity, taxonomic appropriateness, toxicological appropriateness (i.e., chronic thresholds), and strength of data, a value of 2.6 ppm dietary selenium was selected for DS. This value was derived (see Dilution Standard Appendix) from risk relationships presented in the Cumulative Impacts Report for Tulare Basin evaporation basins (CH2M HILL et al. 1993).

One practical problem with a dilution standard based on a dietary exposure is that measuring selenium in foodchain organisms is not the same as measuring dietary exposure. Different foodchain organisms are contaminated to different levels, and some foods that birds feed on may not even be sampled by the field techniques available to researchers. Concentrations of selenium in avian tissues, however, are good indicators of dietary exposure (e.g., Heinz et al. 1989). Ohlendorf (1989) states that the bioaccumulation factor for uptake of selenium from an avian hen's diet to her eggs generally varies between about 1 to 3. Using the midpoint of that range (a factor of 2), the typical dietary

exposure of birds to bioavailable selenium at an evaporation basin can be estimated as one-half the mean concentration of selenium in recurvirostrid eggs collected from that basin. Selenium concentrations in avian tissues provide a biologically relevant integration of local contaminant conditions that is not provided by measuring water or foodchain concentrations of selenium. Among the various tissues that could be utilized as indicators of dietary exposure, we prefer eggs because recurvirostrid eggs are already known to correlate very well with local contaminant conditions (e.g., Ohlendorf et al. 1993; Skorupa 1994), and because compensation monitoring already requires systematic measurement of egg selenium.

The desired dilution effect therefore, is to provide enough alternative habitat within the functional landscape of each hazed evaporation basin to ensure that hazed birds, on average, will be exposed to no more than about 2.6 ppm bioavailable dietary selenium (hereafter referred to simply as dietary selenium).

DERIVATION OF A SOLUTION

Once a dilution standard (DS) has been chosen, the next step is to solve the problem, "What maximum proportion of an avian population's diet (QMAX) can come from a particular evaporation basin without exceeding the dilution standard (DS)?" The solution depends upon how "hot" the basin diet is and how "clean" the alternative diet is. These variables are referred to as basin exposure (BX) and alternative exposure (AX). Accordingly, for the general case,

$$TX = (BX)(Q) + (AX)(1-Q) \qquad (1)$$

where Q = the proportion of a populaiton's diet obtained from an evaporation basin and TX = the population's average dietary selenium exposure.

It follows that,

$$Q = (TX-AX)/(BX-AX) \qquad (2)$$

For the special case of calculating maximum allowable Q or QMAX, TX = DS and,

$$QMAX = (DS-AX)/(BX-AX) \qquad (3)$$

EXAMPLE: CALCULATION OF "QMAX"

For a dilution standard of 2.6 ppm selenium (DS=2.6; average dietary exposure) and an evaporation basin contaminated to a 5 ppm dietary exposure standard (BX=5; i.e, birds foraging exclusively at the basin would produce eggs averaging 10 ppm selenium), and alternative habitat with a 1.25 ppm dietary exposure standard (AX=1.25; i.e., birds foraging exclusively at alternative wetlands would produce eggs averaging 2.5 ppm selenium), then,

$$QMAX = (2.6 - 1.25) / (5 - 1.25)$$

$$= 0.36$$

Therefore a combination of hazing and alternative habitat to ensure that, on average, birds obtained no more than 36% of their diet from the evaporation basin would be the desired minimum dilution effect.

If the sources of a bird's diet were strictly proportional to the habitat mosaic found within the functional landscape of an evaporation basin, then the ratio of that bird's diet from basin exposure (Q) versus alternate exposure (1-Q) would equal the ratio of evaporation basin habitat (EH) versus alternative habitat (AH).

That is,

$$Q / (1-Q) = EH / AH \qquad (4)$$

and it follows that,

$$AH = (1-Q)(EH) / Q \qquad (5)$$

Furthermore it follows that,

$$AHMIN = (1-QMAX)\ (EH) / QMAX \qquad (6)$$

where, AHMIN is the minimum amount of alternative habitat (AH) required to meet the dilution standard (DS).

Accordingly, if we know the size of an evaporation basin (EH) and have the information needed to estimate QMAX, then we can estimate the minimum amount of alternative habitat required. For instance, if QMAX equaled 0.36 as in the example shown above, and the size of the evaporation basin was 100 acres, then the amount of alternative habitat required would equal about 178 acres [(0.64)(100 acres)/(0.36)]. This solution, however, is for the special case where use of different habitats is strictly proportional to their areas. That would only be true when different habitats are equally attractive. The purpose of altering the design of evaporation basins and hazing the birds, however, is to make evaporation basin habitat less attractive than alternative habitat. This can be incorporated into the general solution for alternative habitat (equation 5) by including a coefficient of relative habitat attractiveness, "K", so that,

$$AH = (1-Q)(EH) / (Q)(K) \qquad (7)$$

Now, if because of hazing and other factors alternative habitat (AH) is actually twice as attractive as evaporation basin habitat (EH), then K=2, and only half as much alternative habitat would be required.

<u>The coefficient of relative habitat attractiveness (K)</u>

The coefficient K, combines into a single number the net effect of all factors that influence the relative propensity of alternative habitat versus evaporation basins to attract foraging birds. The coefficient K increases as the relative attractiveness of alternative habitat increases. Any actions that improve the attractiveness of alternative wetlands, such as excluding hunters or placing the wetlands at an optimal distance from evaporation basins will function to increase the coefficient K. However, the <u>relative</u> attractiveness of alternative habitat can also be improved by diminishing the attractiveness of evaporation basin habitat. Factors such as the physical design of levees, the way water is managed, invertebrate management, and the intensity of hazing (that decrease the attractiveness of evaporation basins) will also increase the coefficient K. As K increases, the acreage of alternative habitat needed to meet a particular dilution standard decreases. Thus, there are two categorical sets of factors that basin operators can manipulate to increase the coefficient K, and thereby decrease alternative habitat acreage: (1) decrease evaporation basin attractiveness and/or (2) increase alternative habitat attractiveness.

Clearly, the highest research priority with regard to the calculation of alternative habitat obligations is to obtain empirical estimates of the coefficient K for different combinations of evaporation basin design and operation, and under differing spatial arrangements of alternative habitat. The U.S. Fish and Wildlife Service and the National Biological Service have already prepared a joint research proposal aimed at collecting data that would begin addressing this critical research priority (Schwarzbach and Barnum 1994). The proposed research will employ radiotelemetry and other techniques to directly document landscape-level patterns of habitat use among waterbirds inhabiting particular evaporation basin/alternative habitat landscape units.

The most valid method for estimating K is to directly estimate Q for a subsample of nonbreeding birds via radiotelemetry. Alternatively, a rough estimate of the coefficient K can be obtained from egg monitoring when birds are breeding at both an evaporation basin and an adjacent alternative wetland. In 1994, only Westlake Farms' south-evaporation-basin/section-3-alternative-habitat complex provided the necessary data.

<u>Preliminary empirical estimate of the coefficient K for Westlake-South</u>

From equation (7) above, it can be derived algebraically that,

$$K = (1-Q)(EH) \ / \ (Q)(AH) \qquad (8)$$

To further illustrate what K represents, consider two 50-acre squares of land lying side by side. Suppose square A is 50 acres of evaporation basin and square B is 50 acres of alternative wetland. Also suppose that there is netting over the 100 acres, in effect forming an aviary, so that any bird released into the aviary will acquire all of its food from squares A and/or B. If each square was equally attractive to foraging birds, then on average half a bird's diet would come from each square and the coefficient K would equal one (K=1 can be verified by substituting the values (1-Q)=0.5; (EH)=50 acres; (Q)=0.5; and (AH)=50 acres, into equation (7) above). If three-quarters of the diet had come from the 50 acres of alternative habitat, and only one-quarter from the 50 acres of evaporation basin habitat, then the alternative habitat would have been 3 times as attractive as the evaporation basin habitat and K would equal three (K=3 can be verified using (1-Q)=0.75; Q=0.25; (EH)=50 acres; and (AH)=50 acres, and equation (7)).

At the Westlake Farms south basin and alternative habitat complex in 1994 the area of alternative habitat (AH) was about 145 acres (H.T. Harvey and Associates 1995), and the area of traditional evaporation basin habitat (EH) averaged 478 acres during early April to early June when sampled eggs were being formed and oviposited (H.T. Harvey and Associates 1995: Appendix B). For birds foraging entirely at the south evaporation basin, recurvirostrid eggs would be expected to exhibit a geometric mean selenium concentration of about 6.0 ppm (based on 1993 sampling by the Service). Thus, BX would be estimated as (6.0)/2 = 3. Based on 1994 sampling by the Service at Westlake Farms' demonstration wetland, birds foraging entirely in the alternative habitat should produce eggs exhibiting a geometric mean selenium concentration of about 2.5 ppm. Thus, AX would be estimated as (2.)5/2 = 1.25. Recurvirostrid eggs collected by the Service in 1994 from the section 3 alternative habitat exhibited a geometric mean selenium concentration of 4.1 ppm. Because, virtually all birds nesting at the Westlake-South-Basin/Section-3 Complex were nesting at Section 3, (4.1)/2 = 2.05 is a good estimate of TX. Thus, by substitution of these estimates into equation (2), Q is estimated as 0.46. It appears, that on average, birds nesting at the alternative habitat acquired about 46% of their diet from the spatially adjacent south evaporation basin (thus 1-Q = 0.54). At EH=478, and AH=145, a preliminary empirical estimate of the coefficient K (from equation (8)) would be [(0.54)(478)/(0.46)(145)] = 3.87.

ALTERNATIVE HABITAT CALCULATIONS FOR EVAPORATION BASINS

To calculate the alternative habitat obligations for evaporation basins in the Tulare Lake region we need values for the following variables:

(1) **DILUTION STANDARD**
DS: For the reasons presented in the dilution standard section above, a dilution standard of 2.6 ppm dietary selenium was selected.

(2) **EVAPORATION BASIN DIETARY EXPOSURE**
BX: Basin exposure is estimated as one-half the geometric mean concentration of selenium in recurvirostrid eggs measured at evaporation basins. Data collected recently, during 1991, and/or 1992, and/or 1993, for selenium concentrations were utilized. In some cases, pre-1991 data has to be employed in order to have a minimum sample of at least 5 eggs for estimating the geometric mean.

(3) **ALTERNATIVE HABITAT DIETARY EXPOSURE**
AX: It is assumed that alternative habitat will be created with clean water and that alternate exposure (on an egg basis) will be comparable to Westlake Farm's demonstration wetland in 1994 where recurvirostrid eggs collected by the Service averaged 2.5 ppm selenium (i.e., AX will be set equal to 1.25 ppm, or one-half the measured egg selenium).

(4) **PROPORTION OF DIET FROM EVAPORATION BASIN HABITAT**
Q : QMAX can be calculated from equation (2) once values for DS, BX, and AX are known. Actual Q's can be calculated from equation (2) once values for TX, BX, and AX are known.

(5) **PROPORTION OF DIET FROM ALTERNATIVE HABITAT**
1-Q: 1-QMAX can be calculated once QMAX has been calculated and likewise for 1-Q and Q.

(6) **EVAPORATION BASIN HABITAT**
EH: For this protocol the area of evaporation basin habitat is simply the structural size of an evaporation basin as recognized by the Regional Water Board. Except for the Alpaugh basins, structural sizes of evaporation basins are taken from a statistical compilation for evaporation basins provided by the Central Valley Regional Water Quality Control Board in October, 1994. The Alpaugh basins are currently inactive, structural sizes consistent with planned reconfigurations of the basins prior to their reactivation (D. Dooley, pers. comm.) are employed for this protocol. It would be preferable to base EH on the functional size of an evaporation basin over the annual cycle (i.e., utilized capacity versus design capacity), but that will be possible only once standardized, verifiable, periodic estimates (such as aerial photographs) of wetted basin surface area are available.

(7) **COEFFICIENT OF RELATIVE HABITAT ATTRACTIVENESS**
K : Based on the calculations presented in the coefficient K section above, a K-value of 3.87 is employed for Westlake-South. For all other basins a default value of 2.0 will be employed until site-specific estimates similar to that for Westlake-South are available. A default K-value of 2.0 acknowledges that, combined with hazing and possibly other design and management actions, any reasonable alternative habitat is likely to have higher relative attractiveness for foraging birds than an evaporation basin. Nonetheless, this value is far enough below the estimate for Westlake Farms South Basin to provide immediate incentive for other operators to create at least some alternative habitat that would allow a site-specific measure of K to be obtained. Of the various default K-values

between 1.0 and 3.87 that could have been chosen, 2.0 was chosen because it also roughly corresponds to an overall alternative habitat ratio of 1:1, the default ratio defined by the SJVDP.

In the special case of the Alpaugh basins which are currently inactive, but propose to reactivate operation after reducing basin size and completely redesigning all levees to a steep-sided configuration, an interim K equivalent to Westlake-South's is allowed. This acknowledges the substantive step such redesign represents toward making basins unattractive to foraging birds. By similar reasoning, the Britz-Davenport basin is allowed the same interim K as the Alpaugh basins because the Britz basin is already designed with steep-sided levees. It would still be in these operators best interest to provide for estimation of site-specific K as soon as possible since it's likely their actual K-values will exceed 3.87.

In the following table, values for the different variables and solutions for alternative habitat requirements are presented for all active evaporation basins and the Alpaugh basins which are only provisionally inactive. It should be noted that when estimated dietary exposure at an evaporation basin (BX) is 2.6 ppm selenium, or less, there are no alternative habitat obligations.

Summary Table for Alternative Habitat Obligations

BASIN	K	DS	EH	BX	AX	AH SOLUTION
BRITZ-DAVENPORT	3.87	2.6	25	8.0	1.25	26 acres
MEYER	2.0	2.6	59	<1.5	1.25	0 acres
RAINBOW RANCH	2.0	2.6	100	5.0	1.25	89 acres
STONE LAND CO.	2.0	2.6	210	1.5	1.25	0 acres
TLDD-HACIENDA	2.0	2.6	1,026	4.1	1.25	570 acres
TLDD-NORTH	2.0	2.6	301	1.75	1.25	0 acres
TLDD-SOUTH	2.0	2.6	1,832	5.5	1.25	1,967 acres
WESTFARMERS	2.0	2.6	542	14.5	1.25	2,389 acres
WESTLAKE-NORTH	2.0	2.6	260	1.3	1.25	0 acres
WESTLAKE-SOUTH	3.87	2.6	740	3.0	1.25	57 acres
PRYSE FARMS	3.87	2.6	30	2.6	1.25	0 acres
BOWMAN FARMS	3.87	2.6	7	7.8	1.25	7 acres
MORRIS & SONS	3.87	2.6	10	4.75	1.25	4 acres
MARTIN RANCH	3.87	2.6	4	5.0	1.25	2 acres
4J-CORPORATION	3.87	2.6	13	4.15	1.25	4 acres
TOTALS			**5,159**			**5,115 acres**

CONCLUDING DISCUSSION

The San Joaquin Valley Drainage Program (SJVDP 1990) concluded that alternative wetlands were necessary as an enabling prerequisite for effective hazing programs at evaporation basins. An intuitive, or common sense, recommendation was made that operating criteria for all "contaminated" evaporation basins (Se > 2 ppb in water) include the provision of alternative wetlands at a 1:1 ratio to evaporation basin acreage. Based on a 1991 memorandum of understanding signed by eight federal and state resource agencies, the 1:1 recommendation is "officially" the current interagency consensus. If this consensus were implemented, it would require the creation of about 5,000 acres of alternative habitat for the evaporation basins that were active as of October, 1994. The SJVDP's recommendation has the advantages of being as easy to understand as the biblical eye-for-an-eye, of not requiring continued research to periodically update, and the advantage of avoiding any pretense of unwarranted precision.

Disadvantages of the SJVDP's 1:1 recommendation are that differing degrees of basin contamination are not recognized once waterborne selenium exceeds 2 ppb. Therefore, the apportioning of alternative habitat obligations among basin operators is not proportional to the contaminant risk associated with each basin. Consequently, there is also no incentive for basin operators to invest in remedial actions (at the basins or at the alternative wetlands) that incrementally reduce contaminant risks.

The Service protocol for calculating alternative habitat obligations attempts to solve a landscape-level dilution problem. Accordingly, our protocol explicitly identifies five major determining factors, including: the acceptable dilution standard (DS), levels of contamination of both evaporation basins (BX) and alternative wetlands (AX), basin size (EH), and the relative propensities of evaporation basins versus alternative wetlands (K) to attract foraging birds. The logical relationships between those five factors are expressed as eight empirically testable equations. Alternative habitat obligations derived by applying those equations to available site-specific data for active evaporation basins also add up to a total of about 5,000 acres because the default K-value was fitted to the SJVDP's recommended 1:1 ratio. The evidence from Westlakes Farms South basin, however, suggests that once site-specific K-values can be determined for most evaporation basins, this protocol will require an alternative habitat ratio of about 0.4:1. Once all traditional evaporation basins have been reconfigured for steep-sided levees, it is likely that the required ratio of alternative habitat will fall substantially lower than 0.4:1.

Our protocol has the advantage of being more responsive to efforts of basin operators to improve the design and management of evaporation basins. Under the SJVDP's recommendations, a basin operator has only two options for reducing alternative habitat obligations. A basin operator can either decontaminate the basin to less than 2 ppb selenium in the water, or reduce the size of the basin. Our protocol is responsive to any reduction in the level of contamination (not just to reduction below 2 ppb waterborne selenium), to reductions in basin size, and to an unlimited myriad of design and management options that influence the relative propensities of evaporation basins and alternative wetlands to attract and affect birds. Consequently, our protocol provides incentives for a basin operator to invest in altering basin design and management.

The Service envisions that the task of setting alternative habitat obligations will be a continuous cyclic process whereby there will be an initial iteration of alternative habitat obligations that would be in effect for a 3-year

period. Any new data collected or research findings reported during that period would be incorporated into the next iteration of alternative habitat obligations, which in turn would be in effect for another 3-year cycle and so on.

Finally, it must be understood that, on a year-round basis, the purpose of alternative habitat is to transform, via dilution, an unsafe evaporation-basin-centered local landscape into a safe local landscape. The purpose of alternative habitat is not necessarily to reduce the number of nonbreeding birds visiting evaporation basins, but rather the relative proportion of feeding time that such birds, whatever their number, allocate to evaporation basins versus clean wetlands. Therefore, alternative habitat obligations are not tied to absolute counts of birds. The amount of dilution effect required to create a BIRD SAFE LOCAL LANDSCAPE is the same whether 1 bird or 1,000 birds are utilizing the landscape. To the extent that alternative habitat diverts breeding birds away from evaporation basins (which may be very substantial), benefits will be accrued by basin operators via reduced compensation habitat requirements which are responsive to absolute numbers of birds because measures of nest densities determine habitat utility (HU) factors (see Compensation Habitat Protocol).

ALTERNATIVE HABITAT PROTOCOL

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