Chapter 5

Bald Eagle Nest Protection

5.1 History of Eagles at Alamo Reservoir

Bald eagles have been observed nesting near Alamo Reservoir since December 1986. Two pair of eagles have been returning each year. One pair, called the Alamo eagles, have nested on a tree snag within the reservoir seven out of the nine years between 1988 and 1996. Another pair, called the Ive's Wash eagles, have nested on a snag within the reservoir two out of ten years between 1987 and 1996. The other eight years, the Ive's Wash eagles have nested on a cliff below Alamo Dam. When the eagles nest in a snag within the area of the reservoir, the nest is in danger of inundation due to rising reservoir levels. Also, if the water level rises a few feet up the base of the tree, boaters approaching the nest can be considered harassment under the Endangered Species Act. The eagles typically build their nests in the fall (October to December) after the dry summer months when the lake tends to be low. Historically, when the eagles have selected a snag, the reservoir water surface has been at the base of the tree or lower.

The problem of nest inundation was not addressed specifically during the BWRCTC study for the *Proposed Water Management Plan* (1994). This study evaluates strategic operation policies to reduce or prevent bald eagle nest inundation and harassment. The resulting impacts on the other interests, including other federally listed species dependant on the riparian corridor downstream are approximated.

5.2 Modeling Eagle Nesting

According to data provided by Greg Beatty, Acting Nonpasserine Birds Program Manager, Arizona Game and Fish Department, the nest sites chosen between 1987 and 1996 were between elevations 1,135 and 1,138 feet. Data for one of the nests shows that the base of the nest is approximately 22 feet above the ground. This means that the base of the tree is somewhere between 1,113 and 1,116 feet. According to Mr. Beatty, the eagles built a nest at the beginning of the 1997 breeding season in a willow snag, five to ten feet lower than previous nests, and about 200 feet west of the previous nest sites. There are numerous snags around the lake, and the exact elevations of possible nesting sites is not known.

In order to simulate the interaction of eagle nesting and reservoir operation, several assumptions were made:

- The Alamo eagles have a 0.778 probability of using a nesting site within the reservoir, based on historical pattern of 7 out of 9 years.

- The Ive's Wash eagles have a 0.20 probability of using a nesting site within the reservoir, based on historical pattern of 2 out of 10 years.
- Both pairs of eagles could nest within the reservoir in any given year.
- Eagles can choose a nesting site elevation between 1,125 feet and 1,138 feet based on available snags.
- Both pairs of eagles will choose their nesting site and the elevation will be known by November 1 of each year.
- Eagles will not build a nest closer than fifteen feet to the surface of the water surface on November 1. (This means the valid nesting elevation range will be reduced if the reservoir water surface is above 1,110 feet.)
- Harassment occurs, due to boat accessibility, at water surface elevation 1,115 feet.
- Eagle young normally fledge by late May, but often remain in the nest through July.

The AlamoSim model includes a probabilistic simulation component that simulates the nesting location of each eagle pair on November 1 based on the above frequencies. This simulation approach consists of using a statistical sampling technique to represent stochastic inputs, and applying these inputs to a model to determine the resulting outputs. This approach is often referred to as Monte Carlo simulation (Hillier and Lieberman 1995). If either of the eagles are simulated to nest within the reservoir, a nest elevation is selected from the available nesting site range. The available nesting site range is represented as a uniform distribution between 1,125 and 1,138 feet, modified by the reservoir water surface elevation. For example, if the water surface elevation is 1,112.5 feet on November 1, the available nesting site range would be 1,127.5 to 1,138 feet. (The lower range is determined by adding 15 feet to the water surface elevation of 1,112.5 feet.) Using this technique, if the reservoir is high enough on November 1, there could be no available nesting sites on the reservoir for that year.

An additional post processing routine was developed to quantify impacts on the eagle nests. The eagle data post processor summarizes the nest elevations for each year a nest is within the reservoir, the number of days the water surface elevation exceeds 1,115 feet when a nest is within the reservoir (representing a nuisance), the number of days the water surface elevation is within 5 feet of the nest, and the number of days the water surface elevation equals or exceeds the elevation of the nest. The post processor also keeps track of the number of inundation events. An inundation event occurs if the reservoir pool elevation reaches the nest elevation during the nesting season. Once a nest is inundated, it is assumed to be abandoned. Under these assumptions there can never be more than two inundation events in a given year, (a maximum of one per nest per year). All of this data is computed for the period November to July and December to May.

5.3 Considering the Threat of Inundation

The probability of the eagles being affected by rising lake levels is subject to the elevation at which the eagles nest, the storage of the reservoir at the beginning of the nesting season, the

inflows during the nesting season, the operating strategy, and the physical constraints on release capacity. To evaluate possible operating strategies to try and prevent negative impacts to eagle nesting due to rising lake levels, some tests were done to characterize the possibility of protection.

Four of the largest flood events from the historical record of daily inflows were used to determine roughly the largest net increase in storage that would occur based on inflow and release capacity. The following events were used:

Start Date	*End Date*	*Maximum Increase in Storage (acre-ft)*
12/01/1940	5/31/1941	58,700
1/1/1978	4/30/1978	146,600
1/10/1980	3/31/1980	202,900
1/1/1993	3/22/1993	115,500

One of the events (1980) would cause water levels to encroach well into the range of nesting elevations *even if the reservoir were completely empty* at the beginning of the floods and maximum releases were made during the floods. This simple analysis demonstrates that the eagle nests can not be protected 100 % of the time without structural modifications to the dam outlet works.

Another analysis was done to gain a better understanding of possible maximum reservoir levels between November 1 and July 31. AlamoSim was modified to simulate operation using optimization based alternative 3G (OBA 3G) from November 1 to July 31, starting over each year from a specified storage level. Results from this analysis show the maximum reservoir levels that would occur when starting from a given reservoir pool level on November 1 and operating according to alternative OBA 3G. Simulations were run for November 1 starting elevations of 1100, 1105, 1110, 1115, and 1120 feet. Figure 5.1 shows the traces of reservoir pool elevations between November 1 and July 31 for the 68 years of inflow with a starting pool elevation of 1,100 feet. Figure 5.2 shows the 68 traces for a starting pool elevation of 1,120 feet. Note that under both starting conditions there are numerous peaks that reach or exceed the potential nesting elevations. Information contained in these multiple event traces was summarized by computing the maximum reservoir pool elevation exceedance probabilities for the different starting elevations. Figure 5.3 contains curves that describe the probability (X) that the maximum reservoir elevation between November 1 and July 31 for a single year will not exceed some value (Y) given a starting elevation of 1100, 1105, 1110, 1115 or 1120 feet. These curves provide the following types of information:

> If the reservoir pool elevation in Alamo this November 1 is 1,100 feet, there is a 0.75 probability that the reservoir pool elevation will not exceed 1,125 feet before July 31, and a 0.93 probability that it will not exceed 1,138 feet. Or conversely,

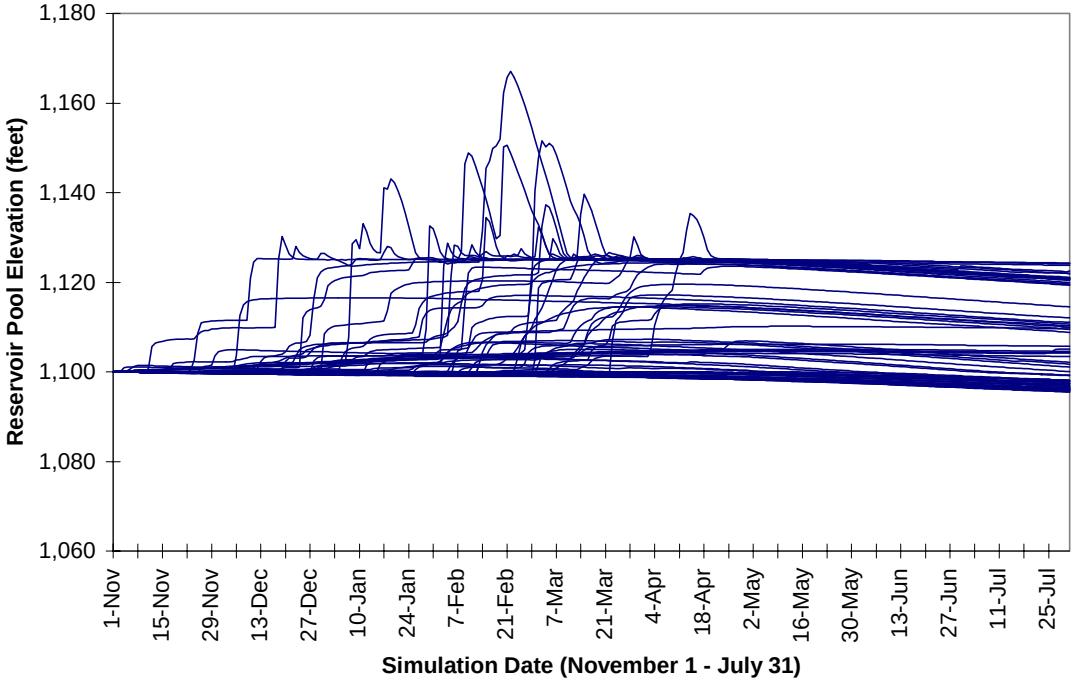

Figure 5.1 Possible Reservoir Pool Elevations Under OBA 3G Starting From 1,100 feet on November 1

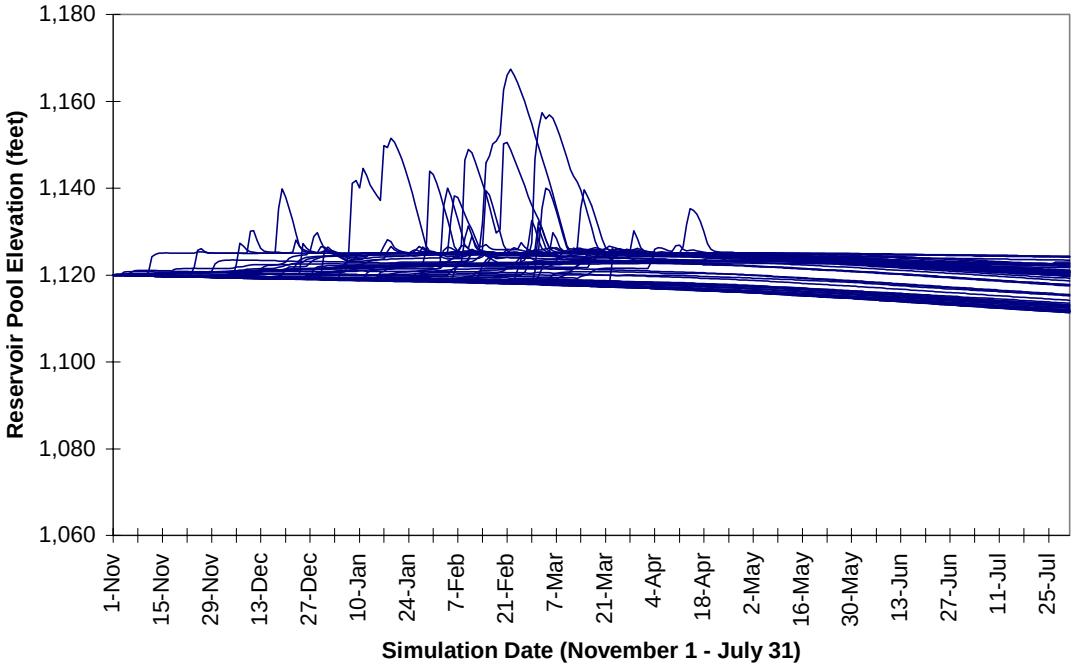

Figure 5.2 Possible Reservoir Pool Elevations Under OBA 3G Starting From 1,120 feet on November 1

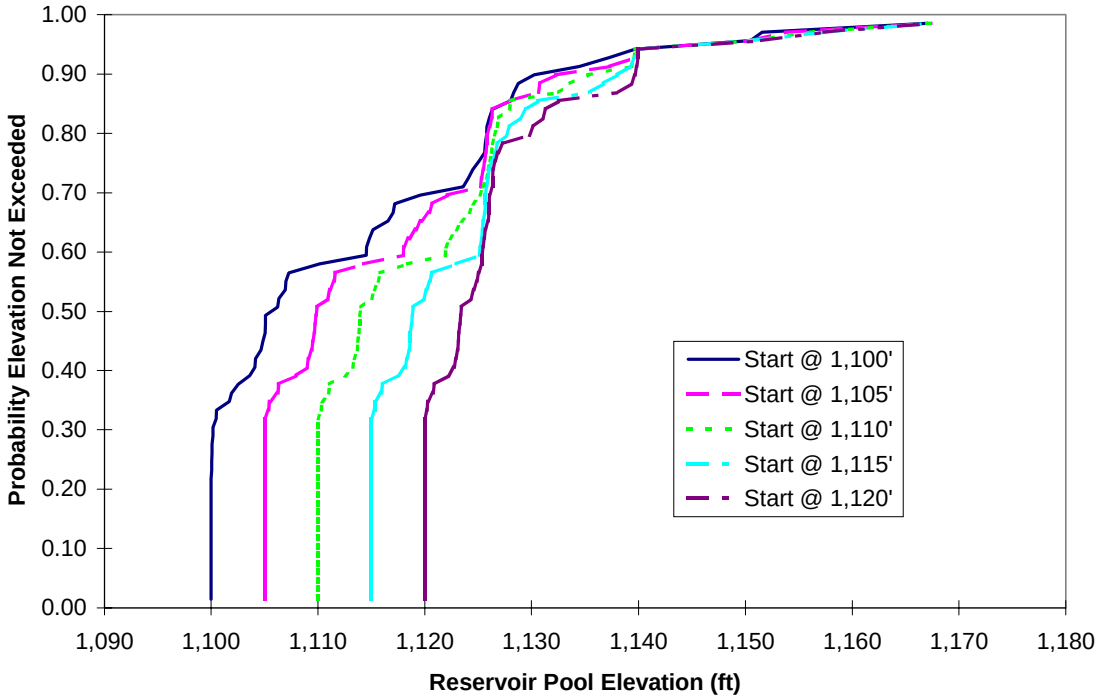

Figure 5.3 Probability of Maximum Reservoir Pool During November through July for Alternative OBA 3G for Different Starting Elevations on November 1

there is a 25% chance that the elevation will exceed 1,125 feet and a 7% chance that it will exceed 1,138 feet between November 1 and July 31.

If the reservoir pool elevation is 1,120 feet on this November 1 , there is a 0.57 probability that the reservoir pool elevation will not exceed 1,125 feet before July 31, and a 0.87 probability that it will not exceed 1,138 feet. This means that if the reservoir level is at 1,120 feet on November 1 and an eagle nest is occupied then there is at least a 13% chance that it will be inundated if no preventative measures are taken.

This position analysis (Hirsch 1978) of possible maximum reservoir pool elevations given different starting elevations demonstrates that a significant flood threat exists any time a nest is occupied within elevations of 1,125 feet and 1,138 feet.

5.4 Negative Impacts on Eagles from Previously Proposed Policies

To approximate the impact on eagle nesting caused by water surface elevations in Alamo reservoir, two previously discussed operating alternatives (Updated Base Case - PFE WD and OBA 3G WD) were tested with the eagle nesting component in the model active. AlamoSim

Table 5.1 Impacts on Eagle Nesting Updated Base Case - PFE WD vs OBA 3G WD

	Alternative	
Criteria	OBA 3G WD	Updated Base Case - PFE WD
IN1	10	12.2
IN2	14.7	18.0
EG1	37.3	37.0
EG2	7.82	8.24
EG3	2.10	2.24
EG4	0.55	0.81
EG5	0.14	0.23
EG6	37.6	37.3
EG7	9.2	9.8
EG8	2.4	2.7
EG9	0.83	1.2
EG10	0.20	0.34
# of Simulations	200	200

IN1 - Number of nests flooded at least once in a year
IN2 - Probability of inundation event occurring in any year (%)
EG1 - Percent of days WSE >= 1,115 during Nov thru Jul (Harassment)
EG2 - Percent of days WSE within 5 feet of Alamo eagle nest during Nov thru Jul
EG3 - Percent of days WSE within 5 feet of Ive's Wash eagle nest during Nov thru Jul
EG4 - Percent of days WSE >= elevation of Alamo eagle nest during Nov thru Jul
EG5 - Percent of days WSE >= elevation of Ive's Wash eagle nest during Nov thru Jul
EG6 - Percent of days WSE >= 1,115 during Dec thru May (Harassment)
EG7 - Percent of days WSE within 5 feet of Alamo eagle nest during Dec thru May
EG8 - Percent of days WSE within 5 feet of Ive's Wash eagle nest during Dec thru May
EG9 - Percent of days WSE >= elevation of Alamo eagle nest during Dec thru May
EG10 - Percent of days WSE >= elevation of Ive's Wash eagle nest during Dec thru May

was run as before on a daily time step between October 1, 1928 to August 29, 1996, except instead of running the simulation once, it was run at least 200 times. The reservoir operation was exactly the same for every simulation, but the eagle nesting elevations could change during each year of each simulation. By running the simulation many times and averaging the results, an approximation of impacts on eagle nesting is made assuming inflows in the near future are similar to those observed over the past sixty eight years.

Evaluation criteria proposed to measure the impacts on the eagle nesting is shown in Table 5.1. The Optimization Based Alternative with flexible draw-down (OBA 3G WD) caused an average of 10 inundation events over sixty eight years of operation. Therefore the probability that a nest will be inundated in any given year is 0.147 when operating according to this operational policy. The Updated Base Case - PFE with flexible draw-down (Updated Base Case - PFE WD) resulted in an average of 12 inundation events over sixty eight years of operation and a 0.181 probability that a nest may be inundated in any year. Also, for both alternatives, the water level is high enough to allow harassment for around 37% of the days during November through July.

If the reservoir is operated according to one of the two alternatives proposed earlier, (including a version of the BWRCTC recommended policy), an eagle nest is likely to be inundated on average every 6 or 7 years and water levels are expected to be high enough to allow harassment from boaters 37% of the time. Figure 5.4 shows the occurrence of harassment and encroachment for both the Alamo and Ive's Wash eagles during November through July according to the two alternatives tested.

5.5 Operating to Reduce the Likelihood of Nest Inundation

Since the analysis discussed above showed that eagle nest inundation could not be prevented 100% of the time, an operating policy was devised to try and achieve a 95% protection rate against eagle nest inundation. The rule form is similar to the other Optimization Based Rule forms discussed earlier. Details for the protection rule are in Appendix F. The simulation for protecting eagle nests against inundation in AlamoSim depends on the probabilistic simulation of the eagle nesting events. If one or two eagle nests are simulated to be active within the reservoir, then the eagles are said to be vulnerable. If the eagles are vulnerable, then the operational policy is switched from the "normal" policy to the protection rule. If the protection rule is invoked, it remains active from November 1 to July 31. The main difference between the protection rule and the "normal" rule is the storage target. If an eagle nest is inhabited, then the storage target is set to 101,000 acre-feet (1,107.3 feet elevation) as opposed to 160,977 acre-feet (1,125 feet elevation) used in the "normal" operation. This lower storage target is necessary to provide storage space in the reservoir to contain flood events while trying to reduce the chance of inundation to 5% or less.

Two eagle protection alternatives were studied by adding the eagle protection rule component to the best two alternatives analyzed previously, (now referred to as Updated Base Case - PFE WD EP and OBA 3G WD EP, where EP indicates eagle protection). Under the Updated Base Case - PFE WD EP, if no eagle nests are vulnerable, then the alternative uses the same operating policy as used in Updated Base Case - PFE WD. If an eagle nest is vulnerable, then the eagle protection rule described above becomes the controlling operating policy. Again, the daily simulation for the period of record was run at least 200 times, with probabilistic simulation of eagle nesting each year. The results were monitored after each fifty runs to

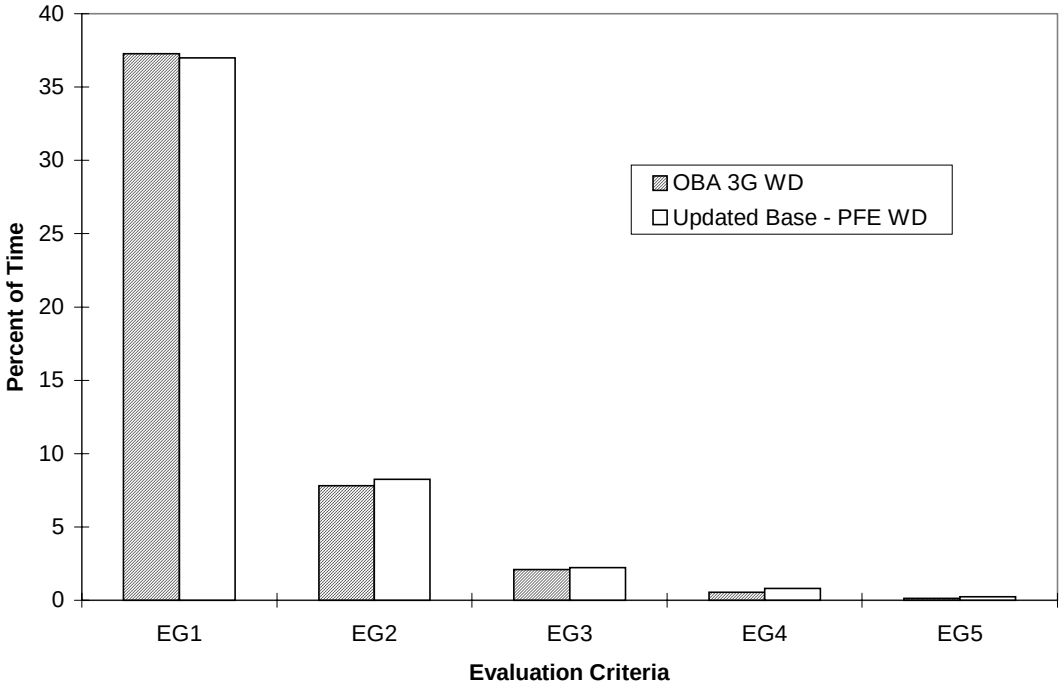

Figure 5.4 Evaluation Criteria for Alternatives without Protection

determine when the model outputs were stable. Table 5.2 contains the estimated impacts to the eagles under the two protection-oriented operating policies. Both alternatives were able to achieve slightly better than 95% protection against inundation events — 9% to 13% better than protection policy. The frequency of conditions deemed to allow harassment is reduced from 37% without protection to less than 1% with protection. The protection strategies reduce, but do not eliminate negative impacts on the eagles' nesting. However, these improvements for the eagles' nesting come at a price of reduced performance for other objectives.

5.6 Performance Trade-offs

As shown above, the operational strategies tested to reduce negative impacts on bald eagle nesting were successful. The frequency of inundation was reduced from 18% per year to 5% per year -- a 72% reduction. Unfortunately, this change in operation also caused a significant decrease in performance for other objectives. Table 5.3 presents a summary of evaluation criteriavalues for the Updated Base Case - PFE WD and the OBA 3G alternatives with and without eagle nest protection. The performance index values shown in Figure 5.6 suggest that the alternatives with and without eagle nest protection. The performance index values shown in Figure 5.6 suggest that the alternatives with eagle protection perform worse overall for storage related criteria, and better overall for flow related criteria.

Table 5.2 Impacts on Eagle Nesting when Protecting Against Inundation

	Alternative	
Criteria	OBA 3G WD with Protection	Updated Base Case - PFE WD with Protection
IN1	3.2	3.3
IN2	4.7	4.9
EG1	0.6	0.7
EG2	0.30	0.30
EG3	0.07	0.08
EG4	0.21	0.20
EG5	0.05	0.06
EG6	0.9	0.9
EG7	0.4	0.4
EG8	0.1	0.1
EG9	0.31	0.30
EG10	0.07	0.09
# of Simulations	200	200

IN1 - Number of nests flooded at least once in a year
IN2 - Probability of inundation event occurring in any year (%)
EG1 - Percent of days WSE >= 1,115 during Nov thru Jul (Harassment)
EG2 - Percent of days WSE within 5 feet of Alamo eagle nest during Nov thru Jul
EG3 - Percent of days WSE within 5 feet of Ive's Wash eagle nest during Nov thru Jul
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EG5 - Percent of days WSE >= elevation of Ive's Wash eagle nest during Nov thru Jul
EG6 - Percent of days WSE >= 1,115 during Dec thru May (Harassment)
EG7 - Percent of days WSE within 5 feet of Alamo eagle nest during Dec thru May
EG8 - Percent of days WSE within 5 feet of Ive's Wash eagle nest during Dec thru May
EG9 - Percent of days WSE >= elevation of Alamo eagle nest during Dec thru May
EG10 - Percent of days WSE >= elevation of Ive's Wash eagle nest during Dec thru May

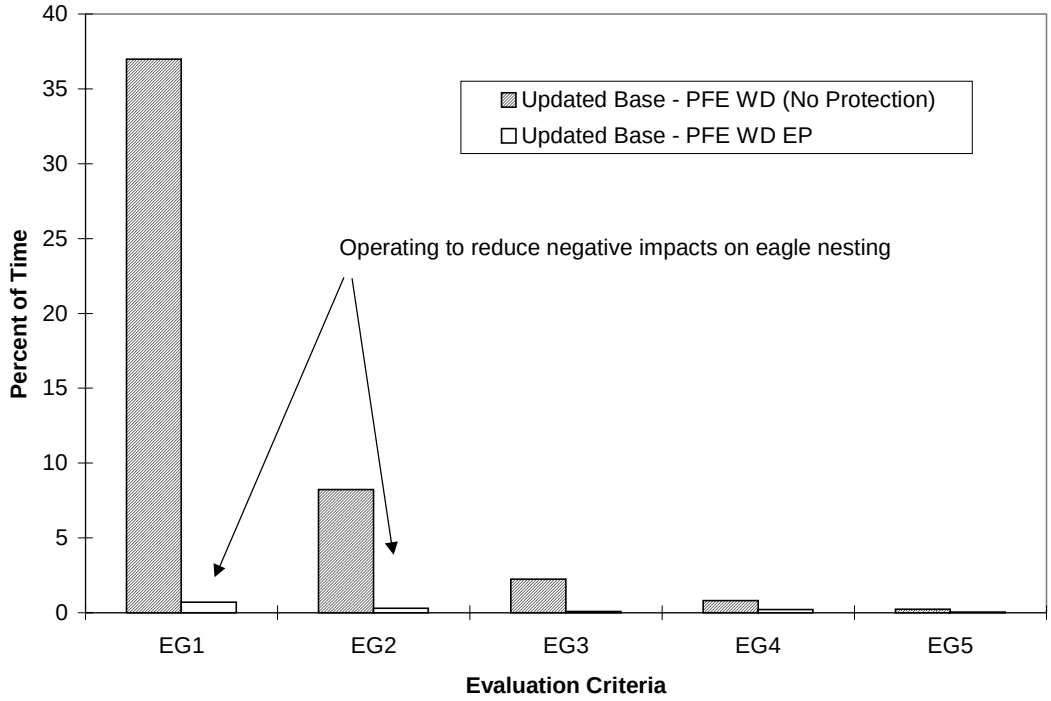

Figure 5.5 Eagle Evaluation Criteria: No Protection vs Eagle Nest Protection

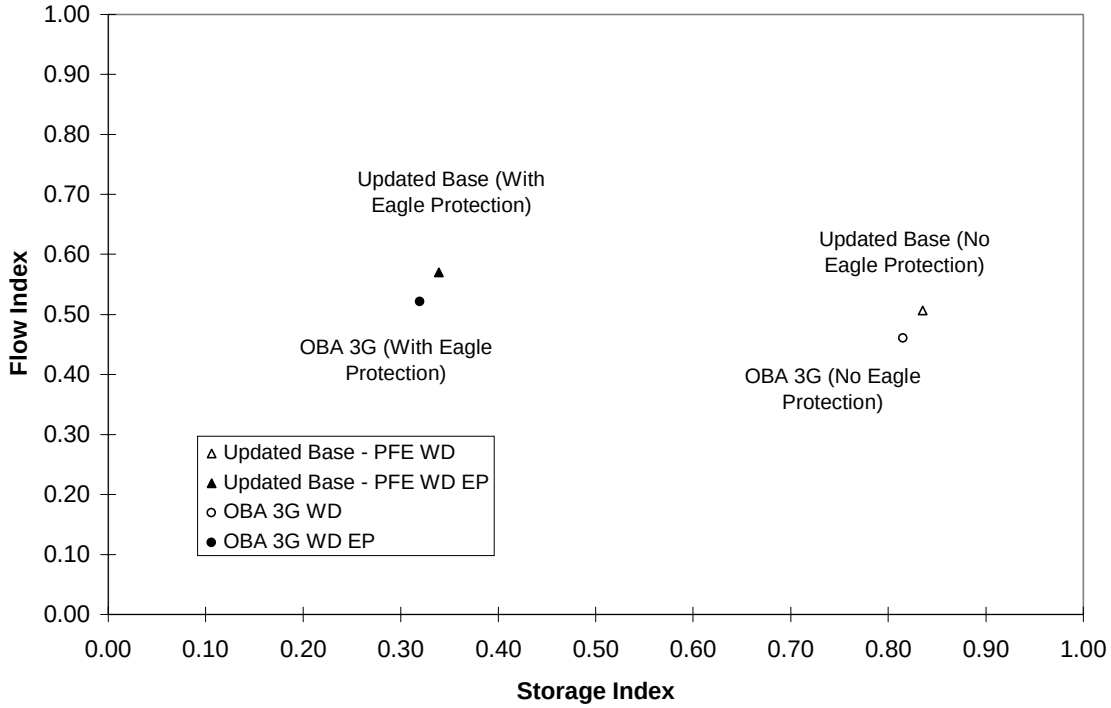

Figure 5.6 Performance Index Values for Alternatives With and Without Eagle Protection

Figure 5.7 offers a direct comparison of evaluation criteria values for the Updated Base Case (including the pulse flow extender and flexible draw-down rules) without eagle protection and with eagle protection. The recreation evaluation criteria values are much worse for the alternative designed to protect eagle nesting as shown in Figure 5.7. The largest recreation related decline occurs for RE3 (percent of time WSE at or above 1,108 feet), going from 60% to only 10% -- an 83% reduction in performance. The eagle protection policy does slightly better for water conservation evaluation criteria with an 8% increase in the average annual delivery to Lake Havasu and a 14% reduction in average annual evaporation from Alamo.

Results for the fishery evaluation criteria are mixed. For instance, the F2 criteria (a measure of lake fluctuation during spawning and growing season) value for the policy with eagle protection is 35% better than the policy without eagle protection, but the value for F1.1 (a measure of how frequently the water level is within a desirable zone in the lake to support spawning and growing) is 84% lower for the protection alternative.

The eagle nest protection policy is designed to reduce the threat to the eagles' welfare posed by the reservoir, but ironically this threat exists because the reservoir is such an attractive site to nest and raise young. The reservoir serves as the primary forage area for the eagles that nest in the basin. In a 1988 letter to the Corps, the U.S. Fish and Wildlife Service requested that Alamo Lake not be drawn down below 1,100 feet to ensure adequate forage area for the two pairs of eagles nesting near the reservoir (BWRCTC 1994). While helping the eagles by reducing the threat of harassment and nest inundation, the protection alternatives also harm the eagles by causing the lake level to drop below 1,100 feet elevation much more often. Figure 5.7 shows that W1, the percent of time the WSE is greater than or equal to 1100 feet, decreases from 78% (with no nest protection) to 53% (with nest protection). Under the scenarios tested, the risk of flooding a nest in a year can be reduced from 18% to 5%, but at a cost of 25% more days that the forage area is below a level deemed adequate.

Operating to protect against eagle nest inundation would also impact other listed species dependant on the riparian corridor. Figure 5.7 shows large decreases in performance for several of the riparian evaluation criteria. Five of the criteria values (RA1 - RA5) are between 27% to 43% lower under the eagle nest protection policy.

These results illustrate one of the most challenging aspects about managing Alamo Reservoir. If the reservoir is managed to try and reduce harassment and nest inundation for the bald eagles, then other listed species are impacted in a negative way. In fact, even the bald eagles are impacted negatively due to more frequent low lake levels.

Table 5.3 Evaluation Criteria Summary: With and Without Eagle Protection

	Without Protection		With Protection	
Criteria	Updated Base-PFE WD	OBA 3G WD	Updated Base-PFE WD EP	OBA 3G WD EP
RE1 (%)	99.6	99.6	98.3	98.4
RE2 (%)	95.2	94.6	89.7	89.8
RE3 (%)	60.0	58.8	10.2	10.0
RE4.1 (%)	40.6	42.1	5.3	5.4
RE5 (%)	0.2	0.1	0.1	0.0
RE6 (%)	3.4	3.0	3.5	3.4
RE7.1 (%)	43.0	45.7	5.7	5.9
WC1 (af)	53,129	53,241	57,328	57,330
WC2 (af)	16,622	16,576	14,229	14,224
FC1 (#)	0	0	0	0
FC2 (%)	0.0	0.0	0.0	0.0
W1 (%)	77.8	77.5	53.4	53.6
W2 (#)	13	12	5.9	5.6
W3 (#)	12	11	5.9	5.6
F1.1 (%)	51.9	53.2	7.9	8.0
F2 (%)	5.4	4.2	3.5	3.3
F3 (%)	27.6	25.8	23.6	23.3
F4 (ft)	9.4	11.0	7.8	7.8
F5 (cfs)	58.0	59.0	40.9	41.1
F6 (cfs)	143.0	143.0	157.5	157.5
F7 (%)	15.9	15.2	17.3	17.3
RA1 (%)	49.6	48.7	35.4	35.4
RA2 (%)	77.8	77.5	53.4	53.6
RA3 (%)	73.3	73.1	41.6	41.8
RA4 (%)	79.6	79.4	56.1	56.4
RA5 (%)	78.7	78.1	57.7	57.9
RA6 (%)	21	21	23.6	24.1
RA7 (%)	25	26	26.7	25.7

Note: Gray cells indicate that lower values are preferred.

RE1 - % of time WSE at or above 1090'
RE2 - % of time WSE at or above 1094'
RE3 - % of time WSE at or above 1108'
RE4 - % of time WSE between 1115' and 1125'
RE4.1 - % of time WSE between 1115' and 1125.1'
RE5 - % of time WSE between 1144' and 1154'
RE6 - % of time Outflow between 300 and 7,000 cfs
RE7 - % of time in March thru May WSE between 1115' and 1125'
RE7.1 - % of time in March thru May WSE between 1115' and 1125.1'
WC1 - Avg annual delivery of water to Lake Havasu
WC2 - Avg. annual evaporation in ac-ft for simulation period
FC1 - No. of days WSE above 1171.3' during simulation period
FC2 - Max percent of flood control space used during simulation period
W1- % of time WSE at or above 1100'
W2- No. of times during the year that WSE exceeds 1135' two or more consecutive days
W3 - No. of times from 1 Dec thru 30 Jun that WSE exceeds 1135' two or more consecutive days
F1 - % of time WSE between 1110' and 1125'
F1.1 - % of time WSE between 1110' and 1125.1'
F2 - % of time in Mar thru May WSE fluctuates more than 2" per day
F3 - % of time in 15 Mar thru May WSE fluctuates more than 0.5" per day
F4 - Max WSE drop, in feet, in Jun thru Sep for simulation period
F5 - Avg. Daily release during Jun thru Sep
F6 - Avg. Daily release during Oct thru May
F7 - % of time stream flows at BW Refuge equal or exceed 25 cfs
RA1 - % of time stream flows at BW Refuge equal or exceed 18 cfs
RA2 - % of time WSE between 1100' and 1171.3'
RA3 - % of time Alamo releases >= 25 cfs in Nov thru Jan
RA4 - % of time Alamo releases >= 40 cfs in Feb thru Apr and Oct
RA5 - % of time Alamo releases >= 50 cfs in May thru Sep
RA6 - Total no. of occurrences that Alamo releases >= 1,000 cfs seven or more consecutive days in Nov thru Feb
RA7 - Total no. of occurrences that Alamo releases >= 1,000 cfs seven or more consecutive days in Mar thru Oct

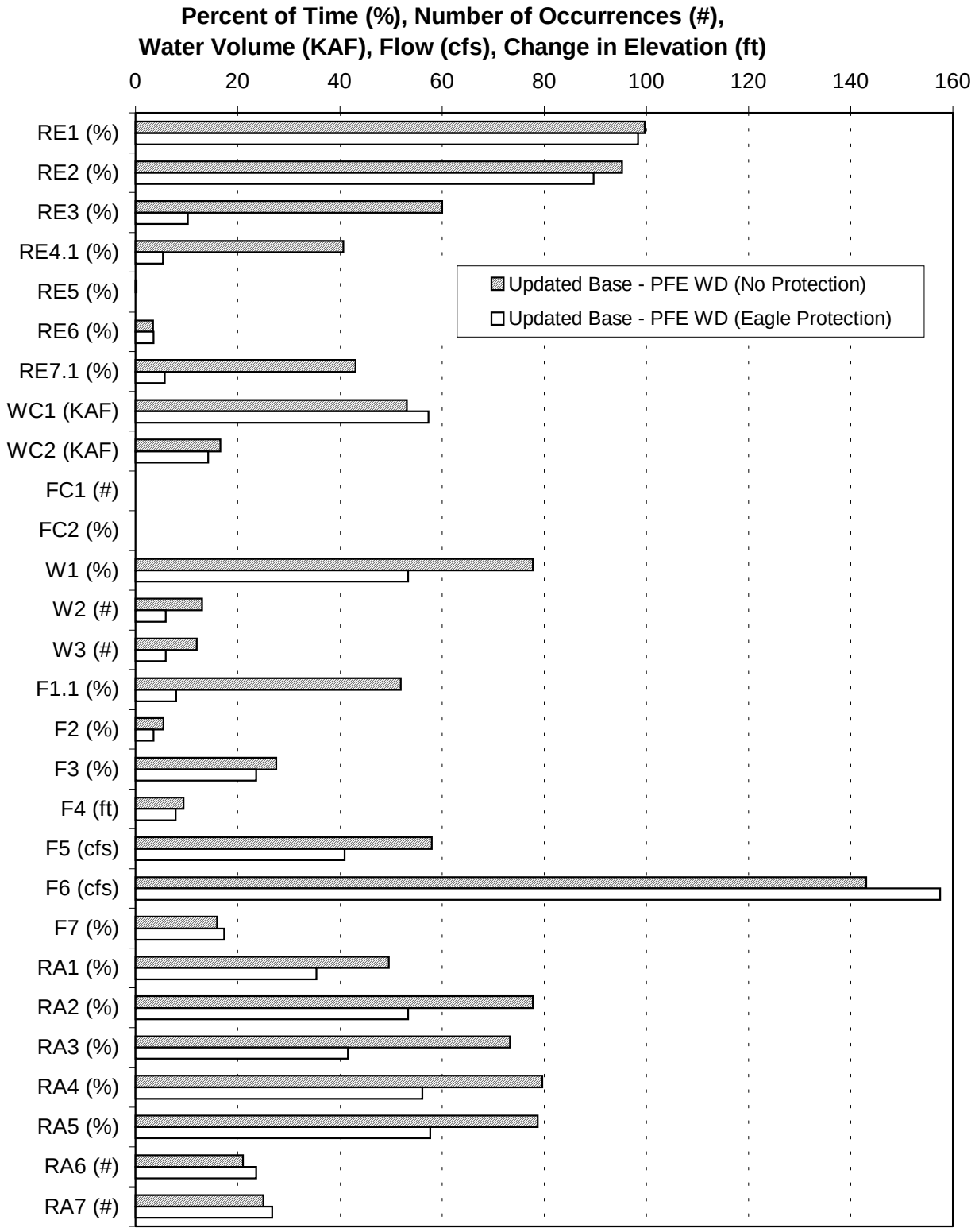

Figure 5.7 Evaluation Criteria: Eagle Nest Protection vs No Eagle Nest Protection