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## Journal
Proceedings of the Vertebrate Pest Conference, 18(18)

## ISSN
0507-6773

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## Publication Date
1998

## DOI
10.5070/V418110137

# CONTAINMENT BASINS AND BIRD EXCLUSION—A HISTORICAL PERSPECTIVE

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ABSTRACT: Most facility engineers with responsibility for hazing birds on containment basins use agricultural crop protection techniques. This approach is appropriate for basins with non-hazardous solutions. Basins containing toxic solutions require an entirely different approach. Detoxification, or exclusion with floating membranes, netting or Bird Balls™ are the best options.

KEY WORDS: Bird control, bird hazing, containment basin, ponding basin, floating membranes, netting

Proc. 18th Vertebr. Pest Conf. (R.O. Baker & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. 1998.

## INTRODUCTION

Conflicts between birds and the operators of ponding basins have always been challenging. Facility engineers that maintain potable water storage reservoirs occasionally have their hands full attempting to exclude gulls, ducks and geese. Contamination levels from the feces of hundreds of these large birds congregating on a drinking water impoundment reservoir have been the impetus for initiating many bird hazing programs. A moderate degree of success in diminished bird numbers is accepted as an accomplishment and a job well done.

Conflicts between birds and the operators of large tailings ponds associated with the processing of soda ash is a more serious issue relative to enforcement of the Migratory Bird Treaty Act. In this industry, the waterfowl and shore birds using the artificial ponds may die from exposure. The fine powdery-like particles in the water dry on the birds plumage, stripping the protective oil from the feathers. Exclusion is not currently feasible on a 100-acre tailings pond so this industry relies on harassment with air boats, sound systems and sophisticated radar tracking devices that launch a battery of pyrotechniques when birds come into the alarm zone.

Conflicts between birds and industrial containment basins containing toxic liquids has become a high stake issue regarding enforcement of the Migratory Bird Treaty Act. In many instances the bird loss rates are much too high in the eyes of industry as well as the regulatory agencies. There are not many facility engineers who like to see dead ducks floating on their ponding basin. But until the last few years, there were not many viable options for excluding waterfowl from basins containing toxic solutions.

The most recent technical breakthroughs for excluding birds from containment basins have been developed as a result of the needs within the precious metals mining industry. The last 10 to 15 years have been a gold rush era in the United States with the State of Nevada becoming one of the top gold producers in the world. This is a result of technical developments in the extraction of microscopic gold with sodium cyanide. The process is called heap leaching.

## HEAP LEACHING DEFINED

This mining process uses low grade ores down to approximately 0.02 ounces of gold per ton. Milling techniques are used for high grade ores but many mines use both techniques with multiple basins containing sodium cyanide. Robert Hallock (retired U.S. Fish & Wildlife Service) has written one of the most succinct definitions of heap leaching. He states that "Typical heap leaching operations involve the placing of ore on an impermeable lined pad. Buffered cyanide solutions are distributed across the surface of the ore (heaps). The solution leaches gold and is collected from the base of the heap on the lined pad. From the pad it is transported to a plastic lined pregnant solution pond (the solution which bears the gold). The gold is then removed from the pregnant solution in an enclosed extraction system. The solution then passes to the barren solution pond. Here, cyanide concentrations are restored to the level necessary for efficient leaching. This barren solution is then recycled across the heaps. Thus solution movement is a circular process.

Cyanide concentrations are highest in the barren pond and the solutions being applied to the surface of the heaps, and concentrations are lower in the collection systems at the base of the heaps and the pregnant solution ponds. Variable amounts of cyanide are consumed during the leaching phase. The typical operation also has an event pond to contain excess cyanide solutions from the heaps during high precipitation events. Cyanide concentrations in this type of pond are highly variable. There are many variations of this typical heap leaching process, some of which diminish or eliminate migratory bird mortality. The best methods are those that deny migratory birds access to cyanide solutions.

### Combined Pad/Pond Facility

The combined pad/pond technique differs from the typical heap leach facility in that the pad is constructed in the form of a reservoir or basin. The heaps are then placed within this reservoir for leaching. The reservoir is sized to allow the porous spaces within the ore heap to serve as space for both the pregnant solutions and emergency holding of additional water that could occur during unusual precipitation events. A series of collection lines and a sump pump are provided to recover the pregnant solutions from the bottom of the reservoir. With this technique there is no exposed pregnant solution pond nor are there collection channels at the heap margins. Savings in cyanide and water may compensate for any additional construction expenses. This technique may be limited by the extent of clay in the ore which could block solution movement and extraction efficiency.

Barren or Pregnant Solution Tanks

Several mine operators have chosen steel tanks in place of traditional exposed, excavated, plastic lined barren and/or pregnant solution ponds. Because the solutions are in steel tanks, they are not attractive to birds. Some tanks are enclosed or indoors and completely unavailable to birds or other wildlife. Common to all observed mines using this technique is a need for an emergency precipitation event pond which may contain cyanide on an irregular basis. As with the combined pad/pond technique, this technique has the potential to conserve both cyanide and water. In addition it allows solution temperature control during winter operations. One or more solution pond(s) may be eliminated and, to the extent this occurs exposure to birds and other wildlife is reduced" (Hallock 1990).

The large number of migrating birds that use these leachate basins as a loafing site has astounded many inside and outside the mining industry. And this seems to be the case even at mines located outside the U.S. because even international mine operators insist on engineering bird exclusion systems into the specifications as part of the bidding process.

## DEVELOPMENT OF CONTROL TECHNIQUES

Hazing

Regardless of the industry, the approach to controlling birds usually starts with what we have seen done in the agricultural setting. Thus, we have overworked purchasing agents looking for a source of flagging, pennants, stretch wires, balloons, pinwheels, reflectors, flashing lights, high intensity spot lights, battery operated radios, sirens, horns, liquid dyes and radio controlled boats and airplanes.

Once the products are acquired, we have high-paid engineers and crews installing and learning how to use these devices. In time it is observed that if birds really want to set down on a ponding basin they will do so regardless of colors, flapping fragments or buzzing bombardments. This empirical process leads us into a second phase of field trials. Agricultural bulletins tell us that one should use a combination of techniques. So we install propane cannons, human effigies, crucified ducks, helium filled raptor balloons, and fire off pyrotechnic devices when the ducks set their wings with determination.

This is not said to criticize bird control research in agriculture. Indeed, we need a data base from which to work. Three examples of good field research that have given hope and direction are the use of reflecting tapes to repel blackbirds in grain crops (Dolbeer et al. 1986); the use of propane cannons, color cueing, and herding as a method of hazing waterfowl in grain crops (Knittle and Porter 1988); and the use of stretch wires to deter or repel birds (Pochop et al. 1990).

Neither are we making a statement about the field work done by operators of containment basins in any industry. After all it has been documented that some of the hazing devices mentioned above deter or repel select species under certain weather and site specific conditions; for example, the use of mechanical hazing devices on chemical evaporation ponds (June 1979); human effigies at tailings ponds (Yonge 1979); sound systems on containment basins (Martin 1980); the use of hazing devices and associated costs at leachate ponds (Sturgess et al. 1989); the effects of sound devices on gulls and cormorants in a confined space (Martin and Martin 1984); electronic bird control in tailings ponds (Patton 1996).

The point is that a distinction must be drawn between the use of hazing to deter birds feeding on a crop and the use of hazing to exclude migratory waterfowl from landing on a hazardous material. In fairness, it must be said that during the infancy of heap leach mining no one dreamed that the containment basins would attract waterfowl. At many sites no one had seen many birds, let alone waterfowl. All too soon it became apparent that these basins located in remote desert regions were a welcomed loafing site for flight-weary, migrating waterfowl. Hopefully, history will not repeat itself when similar circumstances arise in the future.

The result was a scramble to keep waterfowl off the basins. The environmental engineers and plant operators were testing hazing devices to the limit and trying to figure out how to use bird netting to exclude birds from landing in the basins. It did not take long to realize that the only successful system would be a barrier to cover over the top of the basin. Detoxification of solutions has not proved to be user friendly. Non-exposed solution systems are currently being used and may prove to become the standard in the future.

Exclusion

The first attempts at netting containment basins were done with lightweight, agricultural netting and 1/8-inch cable spaced at 20-foot intervals. The perimeter cable anchors were "T" posts driven into the ground. If the first 50-mile an hour wind did not tear the netting off, then the first heavy spring snow collapsed the entire system. Obviously, engineered specifications would be required.

Cable size had to be increased to accommodate break strengths of over 10,000 lbs. The use of PVC coated 7 x 19 strand cable with thimbles on all terminal ends became a necessity. The standard heavy duty cable system with a five foot grid pattern presented some challenges for perimeter anchoring.

Traditional perimeter anchoring systems of pipe and concrete were costly and had unacceptable failure rates. Soil conditions around a typical basin changed dramatically from sand to solid rock, with everything else in between. Sudden spring rainstorms would saturate the soil and allow the cable tension to pull over the pipe and concrete anchoring posts. In time, Duckbills became the industry standard for perimeter anchoring.

The Duckbill Principle

The Duckbill anchor works very much like a toggle bolt. The anchor body is driven into the soil with a re-useable drive road. Once the anchor body is placed to the proper depth, the drive rod is removed. A backward pull on the cable then rotates the anchor body in the ground until it is perpendicular to the cable. This is called load-locking the anchor. Because the Duckbill is usually driven into the earth, it is actually compacting the soil, not disturbing it. As the anchor is load-locked, it cuts through the compacted soil into undisturbed soil and further compacts the soil above the anchor. As the soil above the anchor is compacted from below it forms an inverted cone of compact soil. This is called a cone of resistance.

One of the most important features of the Duckbill anchoring concept is the ability to proof-test the anchor during normal installation. The load locking operation can be a proof-test of the anchor. By measuring the force required to load-lock the anchor, the installer knows the actual holding capacity of the installation.

Soils

Anchor holding capacity will vary in the different classes of soils. More capacity can be expected in the numerically lower classes and less capacity in the higher classes. Knowing the type of soil does not always mean that the class is known. For example, a clay material can have a class ranging from 4 to 8 depending on whether the material is very stiff to hard or soft to very soft. Water content will also affect classification. Similarly, cohesionless soils such as sands and gravels have a wide range depending upon the density or compactness of the material.

There are various ways of testing soils. A torque probe is the best for quick classification in the field. Core samples are the best for detailed classification, but are expensive and take time to obtain the test results. Generally, resistance to driving the Duckbill is a good "seat of the pants" indicator of soil class. Stiff resistance will normally result in positive anchoring. If the anchor drives very easily, the soil is soft and steps should be taken to assure adequate capacity. Keep in mind that simple proof-loading will verify the capacity of the anchor in any soil class.

The anchors are rated in an average (class 5) soil condition. Again, higher capacities can be expected in harder soils and lower capacities in softer soils. The rating is mainly useful as a reference for anchor selection. Proof-loading is the only way to insure the exact capacity of each installation. This is true for all anchors on the market today.

Special Soils Considerations

Soft Soils: In areas where the soil proves to be softer than normal, steps should be taken to assure the capacity of the anchor. Proof-loading is especially useful in soft soils. Guesswork as to the capacity is eliminated. The installer will know immediately if the anchor point is adequate or if further steps are necessary. Backfilling and tamping the hole behind the anchor will yield somewhat higher capacity in most soft soils. Fill and tamp the hole in 3 inch lifts prior to load locking the anchor. Another option is to drive the anchor deeper in an effort to penetrate a harder layer of soil. Larger anchors may need to be placed to achieve the required load. As a last resort, a number of anchors may be placed in a cluster and bridled together to form one point.

Hard Soils and Rock: If excessive resistance to driving occurs, it may be necessary to drill a hole for anchor placement. If the anchor stops moving and is subjected to excessive pounding (especially from power equipment), metal fatigue can occur and the anchor body can fracture. The Duckbill anchor may be placed in a pre-drilled hole in hard dirt or rock and achieve very good results. Hand augers and gasoline or hydraulic powered earth drills can be used to form the hole.

Table 1. Classes of Soils and Prove Values

| Class | Description | Probe Value |
|---|---|---|
| 1 | Solid Bedrock | -- |
| 2 | Dense Clay; Compact Gravel Dense Fine Sand; Laminated Rock; Slate, Schist; Sandstone | Over 600 in./lbs. |
| 3 | Shale; Broken Bedrock; Hardpan; Compact Gravel Clay Mixtures | 500-600 in./lbs. |
| 4 | Gravel; Compact Gravel and Sand; Claypen | 400-500 in./lbs. |
| 5 | Medium-Firm Clay; Loose Standard Gravel; Compact Coarse Sand | 300-400 in./lbs. |
| 6 | Medium-Firm Clay; Loose Coarse Sand; Clayey Silt; Compact Fine Sand | 200-300 in./lbs. |
| 7 | Fill; Loose Fine Sand; Wet Clays; Silt | 100-200 in./lbs. |
| 8 | Swamp; Marsh; Saturated Silt; Humus | Under 100 in./lbs. |

Table Provided by A. B. Chance.

Floating Membranes

Pilot studies in the late 1950s showed that the principle of the floating cover had merit but it took an actual full scale installation to prove that the principle would work on large reservoirs as well as on small scale experimental models. The first commercial floating cover was installed in California in 1964. It consisted of a membrane and a parallel arrangement of 4" by 12" flexi-rigid, closed cell polyethylene floats installed on the underside of the cover with the float ends terminating at the toe of the slope. The termination point determined the inside boundary of the rainwater collection canal while the outer boundary was the top anchor system itself. Vertical wall tanks could also utilize this system in which case the floats terminated in standard fixed distances from the wall to define rainwater collection canals of precalculated capacity. This original floating cover design was patented in 1967 and since then hundreds, if not thousands, of these type covers have been installed throughout the world.

The first floating cover had no weights, cables or columns in the design. It was a stress-free system. Since columns and other support mechanisms added weight (and cost) to the cover, these components were not used. A second feature of the floating cover was its ability to isolate itself from stress due to seismic loadings. In contrast to floating covers, structural covers do not have a natural immunity to loadings of this type since their high inertia must be controlled by the design of proper reinforcement which increases their cost.

The initial floating cover patents in 1967 prompted a flurry of activity in this field and the first variation from a stress-free cover was introduced in Canada in 1974. It was the first stressed cover and depended on a series of cables to provide tension on the cover.

The second variation from the stress-free cover was introduced in 1976. Featuring a continuous weighted tube centered between a set of two parallel rows of floats, the arrangement pulls excess material into a rainwater collection canal and at the same time divides the cover into segments. The location of the canal can be varied depending on the effect the designer is trying to achieve. Rainwater removal is through the reservoir cover membrane, down through the impounded water and out the embankment or wall. The water can also be pumped over the top of the reservoir into an overflow structure.

The use of floating membranes to exclude waterfowl has not been cost effective compared with netting or bird balls.

Netting Selection

Light weight (4 to 8 lbs./MSF with nominal BS 20 to 30 lbs/strand) extruded netting will hold together for a maximum of three years under intense sunlight as long as snow loading is minimal (1 to 3 lbs./sq. ft) and winds do not go over 25 to 35 mph. Light weight systems require cable to be laced internally.

Heavy woven netting (12 to 16 lbs./MSF with nominal BS 65 to 85 lbs/strand) lasts a minimum of five or more years if installed properly. This netting requires the heavy duty cable and anchoring support system mentioned above. These systems will cover a 300-foot span and hold about 24 inches of light snow before failure. Removable net or breakaway systems are required for heavy snow loads.

The mesh size is always a contentiously debated item. Grebes, for example, will walk on the netting and try to get through any opening large enough to fit their head through. They will get their heads stuck in 1 inch mesh and sometimes their feet in 1-1/2 inch mesh. The standard mesh opening is 1-5/8 inch in snow country with grebes. If regulations require 1 inch mesh, an emergency removal system should be designed. Quarterly maintenance is the key to long net/support system life, regardless of the quality of the netting system installed.

Bird Balls™

Bird Balls™ are a hollow plastic ball that floats on any liquid surface. The balls, for the most part, are made out of black-colored HDPE. The most common and durable is the blow-molded ball. The size of the balls range from 10 mm to 150 mm., but the most frequently used ball for outdoor use in large ponding basins is the 100 mm (4 inch), 40 gram ball. Tests have been run with balls of different diameters and weights to determine the best ball to use in high wind conditions.

The first successful use of these balls in the mining industry was undertaken in 1993 by Barrick Goldstrike in North Central Nevada. Barrick owns and operates the Goldstrike Mine which is a gold mining and ore processing facility. Euro-Matic, with whom Barrick worked, is the largest manufacturer of hollow plastic balls in the world. They are located in London and have been manufacturing hollow plastic balls for many different industrial applications.

Why do the balls keep the birds out of a large ponding basin? The assumption is that the balls camouflage the liquid surface and/or that birds attempting to land realize the improbability of a smooth landing and simply move on. This does not mean to say that birds have not landed on the balls or attempts have not been made. It is just that over the past five years there has not been verification of anything except that no birds have been seen floating amongst a million or more bird balls on some of the larger ponding basins.

What about the cost comparison of netting vs. Bird Balls™? The cost of balls will vary, depending on the quantity and shipping destination. In general, the cost comparison between netting and balls is determined by the life of the operation. It is usually cheaper to use netting and maintain the support system for a three-year project. Bird Balls™ begin to pay for themselves in a project that will operate for over three years.

It seems that the overriding factor in favor of using Bird Balls™ is zero maintenance and the ease with which the balls can be used. For example, the balls form a blanket or cover over the liquid surface, but still allow free access. When sufficient balls are poured onto a liquid they automatically arrange themselves in a blanket over the entire surface, giving a physical cover of 91% of the area when using the 100 mm (4-inch) diameter ball. The good news is that this blanket of balls is not an impediment to equipment that needs to be brought out of or placed into the basin. Balls are simply pushed aside but quickly resume the cover as the equipment moves through the liquid.

In the case of tanks, regardless of the shape, the balls always provide a constant cover. If the liquid level is reduced in a tank or basin causing the surface area to shrink, the balls simply stack in a double layer. When the liquid rises, expanding its surface area, the balls automatically spread out again into a single layer.

Another benefit that Bird Balls™ provide is the reduction in the evaporation rate. This is important at some sites, but other operations need to increase evaporation. One of the more recent thoughts has been to float PVC pipe with irrigation sprinklers in and among the Bird Balls™. The increase in surface area provided by the spherical balls should go a long way toward increased evaporation. Because the balls are black and hollow, the surface temperature of the balls will augment an increased evaporation rate. The balls also will help maintain the operating temperature of the liquid.

One of the most rigorous tests of Bird Balls™ was conducted by Bear Track Mine near Salmon, Idaho. During the first winter of operation the balls were covered with several feet of snow, with occasional ice sheets breaking away from the side slope, mounding the balls up into a heap and then freezing at night once again. During the day, as the large mounds of ice and snow partially melted, the balls would move into any exposed area created by the melting ice. The balls and liquid surface would freeze once again at night and the process began over again the next day. The result was that the balls continued to keep pace in covering any area exposed by melting ice and snow.

Table 2. Bird Ball™ Material Selection and Chemical Resistance

| Specifications | | | |
|---|---|---|---|
| Diameter (mm) | Average Weight (g) | Number per $ft^2$ | Number per $m^2$ |
| 10 | 0.2 | 1076 | 11,600 |
| 20 | 1.0 | 270 | 2,900 |
| 25 | 1.5 | 172 | 1,850 |
| 38 | 4.5 | 74 | 800 |
| 45 | 7.0 | 53 | 570 |
| 50 | 8.0 | 43 | 465 |
| 70 | 16.0 | 22 | 235 |
| 100 | 40.0 | 10 | 116 |

Polypropylene (PP)—Able to withstand continuous working temperatures of 230°F (110°C) and suitable for contact with most chemicals used in the metal treatment industry.

High Density Polyethylene (HDPE)—Suitable for working conditions up to 176°F (80°C). HDPE is recommended for external applications due to its enhanced resistance to freezing conditions. Black, Ultra Violet stabilizing additives prevent the degrading effects of sunlight.

PVDF—This material offers significant increase in operating temperatures up to 320°F (160°C), providing resistance to many aggressive chemicals where alternative plastics would fail.

Table 3. Evaporation test results by covering an open tank.[1]

| | | Hourly Heat Consumption | Evaporation Rate Per Hour |
|---|---|---|---|
| Open Tank | 10.73 kW/h | 13.00 lt/m$^2$ | 24.00 lbs/yds$^2$ |
| With One Layer Balls | 2.7 kW/h | 1.67 lt/m$^2$ | 3.10 lbs/yds$^2$ |
| With Two Layer Balls | 2.04 kW/h | 1.28 lt/m$^2$ | 2.35 lbs/yds$^2$ |
| One Layer Saves | 75% heat | 87.2% liquid | |
| Two Layers Save | 81% heat | 90.1% liquid | |

Calculate the results from above test on a continuous yearly base, 8,700 hours.

With one layer of Euro-Matic Balls: Saving of heat for 1.1m$^2$ (12 feet$^2$). Yearly 70,000 kW/h. Saving of liquid 99.000 liters per m$^2$ per year.

With two layers of Euro-Matic Balls: Saving of heat for 1.1m$^2$ (12 feet$^2$). Yearly 83,000 kW/h. Saving of liquid 102.000 liters per m$^2$ per year.

[1]Ball Size: 38 mm (1-1/2 in.)
Tank Size: 1.85 x 0.6 m (1.1 m$^2$)
6 ft x 2 ft (12 ft$^2$)
Temperature: 90°C (194°F)

Test carried out by Technological Institute, Copenhagen, Denmark. Ask for report.

## CONCLUSION

From the simple beginnings of using rock music to flashing lights, and flags to stretch wire, a black box type of ultrasonic sound device, colored dye and detox processes, it became apparent that the only practical solution to keeping birds off of a ponding basin is some means of exclusion. Netting works, but it requires vigilant maintenance. The use of Bird Balls™ seems to be the answer for the long term project.

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