HTETCO a Zoo and Aquarium Exhibits

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SECTION 1: INTRODUCTION

Every project type accommodates components unique to its industry, whether bedding and linen for hospitality projects, medical equipment for healthcare projects, or technical audio-visual equipment for briefing centers. Zoo and aquarium exhibits are also specialized. The purpose of this paper is to highlight unique characteristics of these types of exhibits and discuss estimating approaches to ensure estimates are built upon a strong foundation and are robust.

When dealing with unique aspects of zoo and aquarium exhibits, the estimator needs to know what questions to ask. Having enough subject matter knowledge will facilitate asking the right questions (and even knowing what to ask), particularly during the early stages of the design phase when many gaps in the design information exist and are to be expected.

This paper does not intend to recommend preferred design solutions or offer unit pricing information, since costs vary significantly from project to project and location, but rather equips the estimator with enough information to ask appropriate questions. A Sample Cost Estimate for an elephant exhibit is included at the end of this technical paper for reference. Vendor references are also provided to assist a first-time exhibit estimator.

Main topics include:
- Interpretives
- Audio Visual Equipment
- Media Content
- Animal Barriers
- Animal Capital Cost & Transportation
- Animal Husbandry
- Rockwork
- Landscaping / Foliage
- Pool / Water Body Construction
- Life Support Systems
- Acrylic Panels

SECTION 2: FACTORS THAT AFFECT TAKEOFF AND/OR PRICING THAT ARE UNIQUE TO THIS PROJECT

The following subject matter knowledge is essential to be an effective estimator for zoo and aquarium projects:

INTERPRETIVES

Interpretives or interpretive signage are the educational signage that accompany exhibits. They typically provide background information about the animal being housed such as geographical habitats, origin, diet, and other species information including its protected or endangered status.

These are incorporated into every zoo project. Traditionally, signage comprised solely of exterior grade, durable materials with the ability to withstand a variety of weather conditions and physical contact by thousands of guests (e.g. embossed on metal or printed on vinyl). Today, many exhibits include interactive elements or video monitors to replace or supplement traditional methods.
Data for collection of Interpretives include:

1. Materials – Panels and lettering type for traditional signage and/or media-based displays.
2. Sizes – Overall square footages.
3. Quantities – Typically there is one panel in front of the exhibit but there could be secondary panels depending on size of exhibit frontage.

Armed with this information it is relatively easy to apply appropriate costs for the interpretives using cost / sf based on previous projects, also referred to as historicals. If this is not available, then vendor pricing should be sought and kept in a database for future reference.

Note: Look out for additional framing or foundation requirements. The Sample Cost Estimate includes pricing for interpretives.

Audio Visual Equipment

As you walk around a zoo, you may hear many different sounds, some are natural while others are artificial and piped through speakers within the space to provide an immersive environment. Sounds may include birds, a variety of animals, wind, rain, etc. In addition, there may be monitors and screens to provide visual interest as well as information (e.g. wait times, special events, and shows).

Pricing these components requires the following information:

1. Number of speakers - Quantities can be estimated during the early stages of design based on known metrics, such as 1 speaker per 20’ of pathway or an allowance based on sf of landscape per speaker.
2. Extent of “point source” speakers – These are speakers that have specific messages and may be triggered or are “show controlled” (the use of automation technology to link together and operate multiple entertainment control systems in a coordinated manner), as guests walk by.
3. Number and size of monitors / screens - Restaurants often have digital menu boards and the zoo may have a central display screen for large advertisements.
4. Systems playback - A centralized location for playback of these systems (location, sophistication, number of racks).
5. Media content – Content played through the speakers and displayed on the monitors.

Pricing speakers is straightforward with historicals or vendor input (note: Point speakers can cost thousands of dollars). Pricing of monitors can also be obtained once a size is known (e.g. 55” LCD monitor). If using internet sources, ensure commercial grade equipment is used for pricing.

In all instances, brackets, supports and the need to theme the encasement with shrouds and covers to fit in with the surrounding environment or simply to be hidden, must be a consideration, the extent varies from zoo to zoo. Consider Disney’s Animal Kingdom which is incredibly immersive in comparison to a local petting zoo, each has vastly different levels of theming.

Pricing the playback equipment can be performed by using historicals and vendor input. It is important to identify the location of the playback equipment and racks to capture the appropriate electrical infrastructure requirements (conduit wire, cable tray etc.).

A verification check should be performed once all items are priced. This can be done by taking the overall cost of the AV systems hardware and deriving a cost / sf (excluding media production which would skew any metrics) as a comparison to other projects.

Media Content Production

This is a specialized field in and of itself. The estimator must confirm if the cost of the media is to be captured in the cost estimate. For example, if an area of the zoo is supplemented with bird sounds played through speakers, are those sounds “off-the-shelf” sounds that can be purchased and played through the playback device or do they need to be produced specifically for the zoo. There is a very big difference in cost between these two options. Similarly, for the visual media, what type of content will be playing, who produces it, and should those costs be captured in the estimate?

Animal Barriers

As one can imagine, animal barriers play a big part in estimating zoo exhibits, particularly when larger animals are involved. Consider the needs for elephant barriers compared to enclosures housing emus!

For larger animals, the barriers need to be robust and strong enough to withstand active load forces of thousands of pounds. Electrified and spiked fencing may also be incorporated into the design for safety. More and more projects now try to adopt design solutions for guest and animal safety by using glass or clever terrain and elevation changes to ensure safe distances.

Note that the construction of barriers could range from poured in place concrete or masonry walls to steel tube railing wrapped with FRP (Fiber Reinforced Plastic) for a themed look (i.e. like wood products). The foundations and thicknesses of the walls drive the cost and are determined by the animal type being housed (compare needs for an elephant versus an otter exhibit). If FRP wrapping is used, one should develop a surface area and then apply an appropriate cost / sf.
Elephant barriers are a good example of a unique item requiring vendor input to obtain current pricing, unless recent historicals are available for the same locale (which is unlikely). Costs run in the hundreds of thousands of dollars (the Sample Cost Estimate incorporates elephant barriers).

Smaller animals such as monkeys, small cats, and birds, often use containment mesh, cables, and cages for housing. The snippet below is an example of vendor pricing for animal containment fabricated from mesh and cables:

\[
\begin{align*}
2' & \text{ can be made in } 3/4', 1/16', 3/32' & \text{ and } 1/8' \text{ cable and runs } $7.50-13.50 \text{ soft.} \\
1/16' & \text{ commonly used for small cats, size primates (lemur, gibbons)} \\
3/32' & \text{ commonly used for larger monkeys (baboon) and mid-size cats—leopard, jaguars and mountain lions where there will be close proximity to zoo staff or guests} \\
1/8' & \text{ usually reserved for chimps} \\
3' & \text{ mesh can be made in all 4 sizes of cable but usually } 3/32' & \text{ and } 1/8' \text{ runs } $6.50-9.00 \\
3/32' & \text{ commonly used for mid-sized cats on perimeter and rooflines} \\
1/8' & \text{ commonly used for gorillas, tigers and lions.} 
\end{align*}
\]

**Animal Capital Cost & Transportation**

The cost of the animals is often excluded from the cost estimate (generally, the owner carries and manages budgets for animal purchases separately). However, it is worth exploring everything associated with bringing livestock from point of purchase to the final habitat to ensure clarity regarding what exactly is to be excluded from the estimate.

The animal supply chain can include the following:

1. **Point of purchase** – Establishes where the animal will be sourced from (could be local, national, international).
2. **Holding Costs prior to transportation** – It is unlikely that all animals required would be purchased at the same time and transported. There is likely to be a gap between actual purchase and transportation, therefore costs associated with a holding station, general care, feeding, and medical costs need to be accounted for.
3. **Transport** – There are specialized companies that transport animals from point of purchase to delivery location. Special cages and transport vehicles are used.
4. **Quarantine costs** – Once transported, it is unlikely that animals will be allowed to go straight to their final destination without a period of quarantine to ensure they do not have health issues.
5. **Off-site / Acclimatization** – There may need to be an acclimation period required to limit trauma prior to exposure to guests.
6. **Veterinarians / Support staff** – Costs to accompany animals during travel and cover additional staff during the settling period.

Below is an example of a cost worksheet including costs of capturing animals, holding costs, transportation, and staff (for a project in Hong Kong using HK $).
Animal Husbandry

Soft costs associated with additional staff to support on-site teams may be required. This could include trainers, veterinarians, curators, specific animal experts, and experience designers overall for the zoo. This is relevant if the estimator is expected to capture all design fees in their estimate or to ensure their list of exclusions captures these disciplines.

Below is an example of staff and support costs (costs also in HK$)

<table>
<thead>
<tr>
<th>Staff</th>
<th>Curator</th>
<th>Veterinary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meal Expenses</td>
<td>Accommodation</td>
<td>Airline</td>
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<tr>
<td>Mammal</td>
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<tr>
<td>Polar Bear</td>
<td>280,000</td>
<td>211,000</td>
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<tr>
<td>Atlantic White</td>
<td>324,000</td>
<td>216,000</td>
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<tr>
<td>Killer Whale</td>
<td>432,000</td>
<td>422,000</td>
</tr>
<tr>
<td>Vervet</td>
<td>270,000</td>
<td>211,000</td>
</tr>
<tr>
<td>Harbour Seal</td>
<td>270,000</td>
<td>211,000</td>
</tr>
</tbody>
</table>

Rockwork

Rockwork has an essential role in creating environments within zoos. There are a few drivers that influence the cost of rockwork:

- **Height** – rockwork requires more structural steel support and the higher you go, the larger the steelwork “cake” to support it.
- **Complexity** – this will vary from project to project and is dictated by the desired design intent. Steel for rockwork can be field fabricated by bending steel bars to desired shapes or produced using “chip and tabs,” (typically for taller more complex designs) where chips are designed using 3D software and delivered to the site for assembly and attachment to the tabs.
- **Proximity to water** – any steel that is close to water will need to be stainless or possibly encapsulated. Stainless steel is preferred due to the complexity involved in ensuring any encapsulation is watertight. However, stainless steel comes at a price as the difference in material cost can be significantly higher over mild steel or low carbon steel.

Metrics to estimate quantity of steel tonnage can be derived by taking the total tonnage from similar projects and dividing it by the surface area.

**Landscaping / Foliage**

Landscaping within exhibits and in general areas of a zoo may be designed around geographical habitats of the animals living in regions such as the Amazon Rainforest or the Sahara Desert. This provides authenticity for guests and is critical to the acclimatization of the animals. It is important to clarify this with the designers as there may be premium costs to capture, including:

- **Shipping** – Shrubs and trees may be sourced from all over the country or overseas. Costs are heavily influenced by size, whether the plantings are saplings or mature trees.
- **Potential need for a tree farm** – Some projects may procure saplings and have an on- or off-site tree farm to grow the trees to a certain level of maturity before final placement when the exhibit / project is completed. If mature trees are delivered, craneage costs will need to be factored.
- **Specimen trees and shrubs** – It is worth clarifying with the design team the extent and nature of specimens, as these can be far more costly than non-specimen plantings.
- **Special construction** – This may include the construction of a greenhouse to house plants and shrubs that may not survive in open areas of the zoo.
- **Irrigation** – General shrub irrigation, drippers, isolated systems, and the resulting controllers for different zones.
- **Maintenance** – Estimates often include an allowance for maintenance for a minimum of 6 months from the date of opening.
HTETCO a Zoo and Aquarium Exhibits ... continued

- Soft Costs - If the cost estimate is to include soft costs, then costs for a horticulturist must be factored in.

Pool / Water Body Construction

Some form of water retention basin is often required for exhibits, whether housing an otter, penguin, or a sea lion. Shotcrete construction is predominantly used for the animal pool construction and costs can be derived based on the square footage involved (walls and slab). The costs need to allow for waterproofing and lighting. Water treatment for the pools is captured below.

The Sample Cost Estimate includes costs for pool construction.

Life Support Systems (incl. Water Treatment)

Life Support Systems (LSS) are unique elements to environments with animals and often comprise a significant portion of the overall cost. Costs should be isolated from mechanical systems for comparison purposes as the estimator moves from project to project.

LSS comprise of the following:

- Heating / cooling for animals
- Filtration requirements in water habitats
- Feeding equipment

During the early stages of a design, the estimator needs to know something about the animal being housed to understand whether heat (e.g. as for snakes) or water filtration (e.g. for seals) is required, and to have a better understanding of the main LSS components needed for the particular animal (filters, skid system, Ultra Violet, etc.).

With this information relevant questions can then be asked such as:

- Water turns per hour (to ensure the appropriate equipment is factored).
- Size of exhibit (to ensure the appropriate number of heaters are accommodated).

Metrics including cost / gallon can be used by type of system and animal in the exhibits. Water treatment equipment for larger animals needs to be able to handle more turns per hour to clean the water and more turns equates to more cost.

Note that the LSS consultant on the team often provides their own benchmarks and are important to keep in the loop as costs are developed.

The Sample Cost Estimate includes priced LSS systems and piping.

Acrylic Panels

Aquariums and water-based exhibits require acrylic paneling. These can be several feet thick to provide the required strength to retain the water and withstand animal collisions (think of a whale). Acrylic panels are often comprised of several pieces of laminated acrylic to reach the required thicknesses and are sometimes priced by the lb. Without good historical data, the estimator should reach out to experts for supply and installation pricing. Note: The desire to limit visible seams can influence the cost.

The chart below was developed using vendor pricing and equations to derive metrics that could be incorporated and used as a historical-base for other projects for different thicknesses of acrylic.
SECTION 3: SPECIAL RISK CONSIDERATIONS RELATED TO THIS PROJECT

The items discussed above are unique to animal habitats and exhibits. If the estimator does not have existing projects to benchmark against then they must reach out to appropriate vendors for pricing checks. The specialized nature of the work often limits a pool of qualified subcontractors to perform the work (compared to general concrete or earthwork trades).

In addition, the zoo or aquarium may have a list of preferred vendors they will only consider for the work. This can create premiums due to limited competition.

There may be constraints that impact productivity or general conditions and requirements. These could include working within the proximity of active habitats, noisy work only being permitted during off-hours, or the need for special training and permits.

All of these risks plus any soft cost considerations and budget allocations should be discussed with the team and incorporated into the estimate (or clearly excluded).

SECTION 4: PARAMETRIC ESTIMATING AND RULES OF THUMB

Pricing of zoo and aquarium exhibits with so many specialized elements generally warrant vendor pricing input. As more estimates are performed, key data can be captured to develop metrics for future parametric estimating, particularly in the early stages of design when specific details and specifications are not available. These same metrics can then be referenced later in the design process when it is time to confirm that detailed estimates fall in line with those established metrics.

Several examples of rules of thumb metrics have already been described, including: Speakers per sf of landscaping, cost per sf of surface area of rockwork, or gallon turns per hour for water treatment.

Internet sources can also be very helpful to gain general knowledge of different animal habitats (zoolex being a very good source) and also for bid results, providing overall costs for different projects (many public zoos publish bid results).

The estimator needs to establish the appropriate cost estimating approach for the item to be priced in the development of the cost estimate.

Below is a sample worksheet deriving metrics for the LSS system of a dolphin habitat. It was prepared using vendor feedback for a project and then used for developing estimates for other projects (the yellow highlighted cells are input cells for use on subsequent projects). Periodically, vendor or bid pricing should be sought to ensure the metrics still apply.

### LSS Quick ROM - Dolphin Pool

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
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<tbody>
<tr>
<td>Reservoir or pond size (sf)</td>
<td>20,000</td>
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<tr>
<td>Reservoir or pond size (depth)</td>
<td>11</td>
</tr>
<tr>
<td>Reservoir or pond size (cf)</td>
<td>220,000</td>
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<tr>
<td>Gallons per cf</td>
<td>7,4805</td>
</tr>
<tr>
<td>Reservoir or pond size (gallons)</td>
<td>1,645,714</td>
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<tr>
<td>Required GPM to circulate all in one hour</td>
<td>21,943</td>
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<tr>
<td>ROM price per GPM</td>
<td>$240</td>
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<tr>
<td>ROM price for above example</td>
<td>$5,206,285</td>
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<tr>
<td>ROM price per total Gallons</td>
<td>$3.20</td>
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SECTION 5: MISCELLANEOUS PERTINENT INFORMATION

There are other aspects to pricing zoo and aquarium exhibit work that will need to be considered as the estimator gains experience and acquires knowledge by simply working on different projects.

For example, the materials used in construction may be determined based on safety to animals (e.g. some materials may be harmful to some animals so there may be a need to swap out the material for a safer alternative or cover the material in some way so the animal cannot gnaw on a harmful substance). Anti-dig mats are another unique item that are often required to prevent animals from escaping exhibits by digging under fencing.
**SECTION 6: SAMPLE PLANS AND TAKE-OFF**

Elephant Exhibit  
Los Angeles, CA  
100% Construction Document Design Stage Estimate  
Project # 20-00XXX  
05/21/20

### SUMMARY

<table>
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<tr>
<th>Element</th>
<th>Area</th>
<th>Cost / SF</th>
<th>Total</th>
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<tbody>
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<td>SITEWORK</td>
<td>215,885</td>
<td>$48.45</td>
<td>$10,459,337</td>
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<tr>
<td>ELEPHANT BARN</td>
<td>17,476</td>
<td>$593.03</td>
<td>$10,363,826</td>
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<td>EXHIBITORY &amp; INTERPRETIVES</td>
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<td>LIFE SUPPORT SYSTEMS</td>
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<tr>
<td><strong>TOTAL HARD COSTS</strong></td>
<td>215,885</td>
<td><strong>$161.62</strong></td>
<td><strong>$34,890,965</strong></td>
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---

[Image of architectural site plan]
## SECTION 7: Sample Budget Estimate

### Elephant Exhibit
Los Angeles, CA  
Project # 20-00XXX  
100% Construction Document Design Stage Estimate  
05/21/20

#### SUMMARY MATRIX

<table>
<thead>
<tr>
<th>Element</th>
<th>SITEWORK 215,885 SF</th>
<th>ELEPHANT BARN 17,476 SF</th>
<th>EXHIBITORY &amp; INTERPRETIVES 215,885 SF</th>
<th>LIFE SUPPORT SYSTEMS 215,885 SF</th>
<th>TOTAL 215,885 SF</th>
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<td>09 Finishes</td>
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<td>14 Conveying Systems</td>
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<td>31 Earthwork</td>
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<td>32 Exterior Improvements</td>
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<td>Total Direct Construction Hard Costs</td>
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<td>$7,397,840 $32,31</td>
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<td>$2,662,262 $12.33</td>
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#### GC Markups & Indirect Costs

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<td>General Conditions</td>
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<td>General Requirements</td>
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<td>Escalation to MOC, 30 Sep 2021</td>
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<td>Total Construction Hard Costs</td>
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For complete sample budget please visit: aspenational.org - Resources - Estimating Today