AQUACULTURE'S BUSINESS NEWSPAPER

Fish Farming News

VOLUME 11 • JULY/AUGUST • 2003 A COMPASS PUBLICATION

Design steps

Key to cost-effective projects

SYSTEMS ENGINEERING

Paul Hundley

Although I have been working on seawater systems for almost 30 years, I sometimes get involved in projects that send me "back to the books" to update my technical approach and "basis of design."

Currently, I am working with the Virginia Institute for Marine Science (VIMS) at Gloucester Point, VA to design a 43,000-square-foot Seawater Research Laboratory with construction scheduled to start in 2004. This lab will support research and demonstration in all aspects of aquaculture, including live feed production, spawning, larviculture, and growout using batch, flow-through, and recirculating culture systems. Other aspects of the lab will include marine environmental research and assessment with regards to diseases, toxic chemicals, and restoration of habitats.

Participation in that project has convinced me of the benefits of reviewing the design issues associated with a large seawater system, the "heart" of a marine aquaculture facility.

In this first column of a two-part series, we'll look at a hierarchy of design needs that must be resolved during the design process using the skills, experience, and methods of the aquacultural engineering team. Part 2 of the review will be presented in the Nov/Dec issue of FFN, and will include specific design features that must be incorporated in the construction of a good seawater system.

In terms recognized and used by many US architects and engineers, the life cycle of a facility such as the VIMS Seawater Research Laboratory includes several phases:

- Programming;
- Schematic design;
- Design development (preliminary design);
- Construction document development;
- Construction and commissioning; and
- Operations and maintenance.

First steps

The "basis of design" is a critical summary and tool that charts the course for detailed design, construction drawings, and, finally, the constructed facility.

The earliest phases of a proposed facility — programming and schematic design — are most critical to overall project success.

Programming establishes the objectives for the facility and is carried out by the project owners, end-users, consultants, and design professionals. Programming concludes with a "written" basis of design.

For the VIMS lab, this entails establishing seawater systems performance criteria that will carry through the design and construction process to become operating systems that support and facilitate the overall objectives of the project once it is built.

Schematic design further qualifies and quantifies various systems and services to establish interrelationships, appropriate technology, and detailed design objectives. This information translates into block diagrams, further performance criteria, and identification of major systems and components.

When integrated through the next phase, design development, the schematic design allows the selection and application of systems and components that will support and facilitate the research and production objectives of the facility.

Schematic design is performed by project consultants and design professionals. The phase concludes with a final, updated basis of design and review and buy-in by the owners and end-users.

Human vs. system

David Schwaller of the Missouri Division of Design and Construction suggests that we follow Abraham Maslow's "hierarchy of human needs" to establish a hierarchy of engineered systems design needs (Fig. 1).

Continued on next page

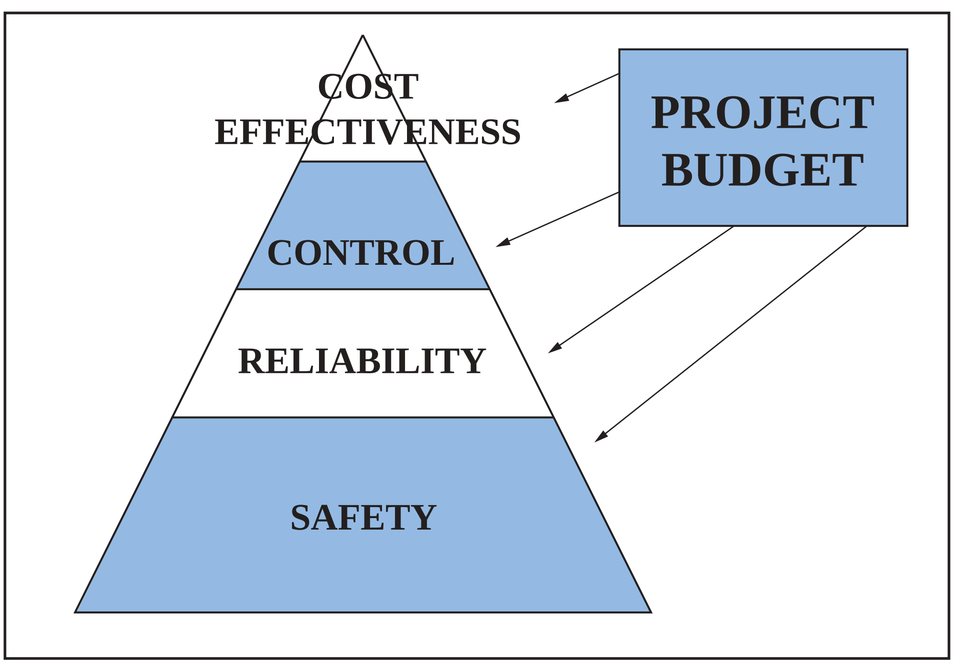

Figure 1: Hierarchy of engineered systems design needs

The premise of the hierarchy in both cases suggests that you have to satisfy lower level needs before going on to those of higher levels.

That means we have to establish a specific set of hierarchical design needs at the beginning of a project and address them during the course of design to realize the overall objectives of our project.

Safety

When it comes to hierarchical design needs, safety is first (Fig. 1). Safety is defined as a measure of how secure a system or component is from threat of loss, danger, or harm.

Clearly, design and construction must adhere to applicable safety codes and standards. An electrical fire could lead to a shutdown of all the facility. Injured employees mean lost work and other financial penalties. An intake failure during a storm could result in no water delivery. The failure of pump bearings due to fouling or corrosion could lead to a catastrophic failure.

For a large seawater system, everything else is irrelevant if you are not prepared to handle these issues with safety in mind:

- Ingestion of foreign materials;
- Storms;
- Rotating machinery;
- Electrical power;
- Heavy pumps;
- Marine fouling;
- Corrosion; and
- Piping support and thrust restraint.

Reliability

Reliability is a measure of the availability of a system or component to perform its required function under all operating conditions.

For a seawater research laboratory, availability of delivered seawater must approach 100%. It must be so reliable that only multiple, major failures could prevent seawater delivery.

Good construction specifications will conform to recognized technical standards in terms of quality, application, and reliability of materials and equipment.

For a large seawater system, design features must also include:

- Emergency power;
- Corrosion resistant materials;
- Redundant systems;
- Engineered spare parts and equipment inventory;
- Bypass arrangements for subsystem maintenance;
- Commissioned systems with full operation and maintenance (O&M) documentation; and
- Trained O&M personnel.

Control

Control is measure of the ability of an engineered system to adequately deliver, restrict, and contain various operating parameters within their prescribed or intended design range; or, in other words, work the way they're supposed to.

Typical seawater parameters include temperature, pressure, flow rate, liquid level, suspended solids, types and quantity of pathogens, plankton, etc.

Further, depending on the seawater's use, relevant effluent parameters can include biota, chemical and pharmaceutical concentrations, pH, and nutrients.

So, the designed and constructed system must apply safe and reliable processes to control the value or range of values for these biological, chemical, and physical parameters.

Applicable processes are many but include:

- Screening;
- Pumping;
- Storage;
- Suspended solids removal;
- Dissolved solids removal;
- Biofiltration;
- Heating and cooling;
- Disinfection;
- Oxidation;
- Chemical adsorption;
- Deionization; and
- pH adjustment.

Cost effective

You probably thought things were relatively easy up to this point. But now, someone has to pay to design, build, and operate this system and its subsystems.

Cost effective is a term we all hear and use, but what exactly does it mean?

I went on-line to the WorldNet Dictionary for a proper definition and found that it means "productive relative to cost." Synonyms include "cost-efficient" and "efficient."

A production mantra that I picked up from the chemical process industry intones the following for cost-effective results: "Tools, Time, Teams, and Training."

- **Tools —** The appropriate tools must be applied throughout the life cycle of a facility or a major system such as seawater.

The idea of "tools" includes: planning and design by experienced professionals; quality control processes such as commissioning; and cost estimating and value engineering, which are important aspects of cost-effective design and construction.

- **Time —** The heart of a good plan is its time line. There must be time for people to resolve and integrate numerous issues during the design phase. Contractors are in the business of being cost effective but need time to do their work with a high degree of quality while dealing with actual project site conditions. In order to achieve full design and production goals, a facility must be adequately staffed.
- **Teams —** Comedienne Lily Tomlin was once quoted as saying, "We're all in this alone." Not! We don't know it all, we can't do it all, and we are more effective as a team than as individuals.

To build a cost-effective facility, the owner-operator needs professional design and construction administration assistance. The design professionals need informational relationships with vendors and specialty contractors.

The owner-operator and design professionals must establish a team relationship with the construction contractor or manager to minimize dispute. The construction contractors or managers need established and sustainable working relationships with subcontractors and vendors. And the O&M staff must have a clear mission, strong leadership, and organizational structure.

- **Training —** The quality of project planning, analysis, evaluation, and execution depends on the training and experience of each and every team member.

The owner-operator must have the right experience or perform appropriate research before engaging in a challenging or risky venture. The design professional's qualifications must include the education, specialty training, and experience appropriate for a particular project. This includes all aspects of analysis and design for a specific discipline, and also includes experience with projects of similar size and scope.

The construction managers, contractors, and subcontractors must obviously be trained in their trade or discipline but they also must have experience with projects of similar size and scope.

And, finally, the facility's O&M staff must be trained in their particular trade or discipline. Even more importantly, the O&M staff must be trained based on appropriate O&M documentation delivered when the project is complete, training that should start for key individuals during the commission phase of the project.

Conclusion

So where are we? What's the message?

The basis of design is a road map, a written plan that should lead to a successful, cost-effective project. It requires us to review and apply appropriate codes and standards. It prompts us to build our project on the foundations of safety and reliability,

Continued on next page

thus assuring its suitability for the marine environment.

It establishes a design and construction "mission" to deliver and control key programmatic or process parameters, making it suitable for the intended biological, chemical, and physical processes.

And, finally, it establishes the analysis, evaluation, and execution that must be performed to lead the team through the design, construction, commissioning, and O&M phases of a project in a controlled, cost-effective manner.

Suggested reading

"Design and Operating Guide for Aquaculture Seawater Systems — Second Edition," by John E. Huguenin and John Colt (Elsevier);

"Development of a Seal Rehabilitation and Marine Science Facility's Seawater and Life Support System," *Aquacultural Engineering 27 (2003) 213 - 245*, by John E. Huguenin, John L. Chase, and Samuel R. Chapman (Elsevier).

This article is based on the full technical paper and presentation currently under development by Paul Hundley for the 2003 Aquacultural Engineering Society Issues Forum to be conducted in Seattle, WA on Nov. 3–5. Part 2 of this article will outline the specific details of a basis of design for a large seawater system.

Hundley, president and principal engineer for Applied Aquatics Inc., a wholly owned subsidiary of RMF Engineering Inc., is located in Charleston, SC. He has more than 30 years experience in the design, construction, and operation of commercial, industrial, and institutional facilities and has been working in aquaculture since 1988. Hundley can be reached via: phone (843) 971-9639; fax (843) 971-9641; or e-mail <AAquatics@rmf.com>. Copies of this and other Systems Engineering articles are available at his web site <www.AppliedAquatics.com>.