2.2 New Larger Intake Structure for Decreasing Intake Velocities

The efficacy of traveling screens can be affected by both through-screen and approach velocities. Through-screen velocity affects: the rate of debris accumulation; the potential for entrainment and impingement of swimming organisms; and the amount of injury that may occur when organisms become impinged and a fish return system is in use. Performance, with respect to impingement and entrainment, generally tends to deteriorate as intake velocities increase. For older intake structures, the primary function of the screen was to ensure downstream cooling system components continued to function without becoming plugged with debris. The design often did not take into consideration the effect of through-screen velocity on entrainment and impingement of aquatic organisms. For these older structures, the standard design value for through-screen velocity was in the range of 2.0 to 2.5 fps (Gathright 2002). These design velocities were based on the performance of coarse mesh traveling screens with respect to their ability to remove debris as quickly as it collected on the screen surface. As demonstrated in the Facility Questionnaire database, actual velocities may be even higher than standard design values. These higher velocities may result from cost-saving, site-specific designs or from an increased withdrawal rate compared to the original design.

As described previously, solutions considered for reducing entrainment on traveling screens are to replace the coarse mesh screens with finer mesh screens or to install fine mesh screen overlays. However, a potential problem with replacing the existing intake screens with finer mesh screens is that a finer mesh will accumulate larger quantities of debris. Thus, retrofitting existing coarse mesh screens with fine mesh may affect the ability of screens to remove debris quickly enough to function properly. Exacerbating this potentia problem is finer mesh may result in slightly higher through-screen velocities (Gathright 2002). If the debris problems associated with using fine mesh occur on a seasonal basis, then one possible solution (see Section 2.1, above) is to use fine mesh overlays during the period when sensitive aquatic organisms are present. This solution is predicated on the assumption that the period of high debris loading does not substantially coincide with the period when sensitive aquatic organisms are most prevalent. When such an approach is not feasible, some means of decreasing the intake velocities may be necessary.

The primary intake attributes that determine intake through-screen velocities are the flow volume, effective screen area, and percent open area of the screen. The primary intake attributes that determine approach velocity are flow volume and cross-sectional area of the intake. In instances where flow volume cannot be reduced, a reduction in intake velocities can only be obtained in two ways: for through-screen velocities, an increased screen area and/or percent open area, or for approach velocity, an increased intake cross-sectional area. In general, there are practical limits regarding screen materials and percent open area. These limits prevent significant modification of this attribute to reduce through-screen velocities. Thus, an increase in the screen area and/or intake cross-sectional area generally must be accomplished in order to reduce intake velocities. For technology options that rely on the continued use of traveling screens, a means of increasing the effective area of the screens is warranted. EPA has researched this problem and has identified the following three approaches to increasing the screen size:

1. Replace existing through flow (single entry-single exit) traveling screens with dual-flow (double entry-single exit) traveling screens. Dual-flow screens can be placed in the same screen well as existing through flow screens. However, they are oriented perpendicular to the orientation of the original through-flow screens and extend outward towards the front of the intake. Installation may require some demolition of the existing intake deck. This solution may work where screen velocities do not need to be reduced by a large amount. This technology has a much improved performance with respect to debris carry over and is often selected based on this attribute alone (Gathright 2002; see also Section 2.1.4).

2. Replace the function of the existing intake screen wells with larger wells constructed in front of the existing intake and hydraulically connected to the intake front opening. This approach retains the use and function of the existing intake pumps and pump wells with little or no modification to the original structure. A concern with this approach (besides construction costs) is whether the construction can be performed without significant downtime for the generating units.

3. Add a new intake structure adjacent to, or in close proximity to, the existing intake. The old intake remains functional, but with the drive system for the existing pumps modified to reduce the flow rate. The new structure will include new pumps sized to pump an additional flow. The new structure can be built without a significant shutdown of the existing intake. Shutdown would only be required at the final construction step, where the pipes from new pumps are connected to the existing piping and the pumps and/or pump drives for the existing pumps are modified or replaced. In this case, generating downtime is minimized. However, the need for new pumps, and the modification to existing pumps that reduce their original flow, entail significant additional costs.

Option 3 is a seemingly simple solution where the addition of new intake bays adjacent or in close proximity to the existing intake would add to the total intake and screen cross-sectional area. A problem with this approach is that the current pumping capacity needs to be distributed between the old and new intake bays. Utilizing the existing pump wells and pumps is desirable to help minimize costs. However, where the existing pumps utilize single speed drives, the distribution of flow to the new intake bays would require either an upstream hydraulic connection or a pump system modification. Where the existing intake has only one or two pump wells a hydraulic connection with a new adjacent intake bay could be created through demolition of a sidewall downstream of the traveling screen. While this approach is certainly feasible in certain instances, the limitations regarding intake configurations prevents EPA from considering this a viable regulatory compliance alternative for all but a few existing systems. A more widely applicable solution would be to reduce pump flow rate of the existing pumps either by modifying the pump drive to a multi-speed or variable speed drive system, or by replacing the existing pumps with smaller ones. The new intake bays would be constructed with new smaller pumps that produce lower flow rates. The combined flows of the new and older, modified pumps satisfies the existing intake flow requirement. The costs of modifying existing pumps, plus the new pumps and pump wells, represents a substantial cost component.

Option 2 does not require modifications or additions to the existing pumping equipment. In this approach a new intake structure to house more and/or larger screen wells would be constructed in front of the existing intake. The old and new intake structures could then be hydraulically connected by closing off the ends with sheet pile walls or similar structures. EPA is not aware of any installations that have performed this retrofit but it was proposed as an option in the Demonstration Study for the Salem Nuclear Plant (PSE&G 2001). In that proposal the new screens were to be dual-flow screens but the driving factor for the new structure was a need to increase the intake size.

EPA initially developed rough estimates of the comparative costs of applying option 2 versus option 3 (in the hypothetical case the intake area was doubled in size). The results indicated that adding a new screen well structure in front of the existing intake was less costly and therefore, this option was selected for consideration as a compliance technology option. This cost efficiency is primarily due to the reuse of the existing intake in a more cost efficient manner in option 2. However, option 2 has one important drawback: it may not be feasible where the sufficient space is not available in front of the existing intake. To minimize construction downtime, EPA assumes the new intake structure is placed far enough in front of the existing intake to allow the existing intake to continue functioning until construction of the structure is completed.

Scenario Description

In this scenario, modeled on option 2 described above, a new reinforced concrete structure is designed for new through-flow or dual-flow intake screens. This structure will be built directly in front of the existing intake. The structure will be built inside a temporary sheet pile coffer dam. Upon completion of the concrete structure, the coffer dam will be removed. A permanent sheet pile wall will be installed at both ends, connecting the rear of the new structure to the front of the old intake structure hydraulically. Such a configuration has the advantage of providing for flow equalization between multiple new intake screens and multiple existing pumps. The construction includes costs for site development for equipment access. Capital costs were developed for the same set of screen widths (2 feet through 140 feet) and depths (10 feet through 100 feet) used in the traveling screen cost methodology. Bets-fit, second-order equations were used to estimated costs for each different screen well depth, using total screen width as the independent variable. Construction duration is estimated to be nine months.

Capital Costs

Capital costs were derived for different well depths and total screen widths based on the following assumptions.

<u>Design Assumptions - Onshore Activities</u>

- Clearing and grabbing: this is based on clearing with a dozer, and clearing light to medium brush to 4" diameter; clearing assumes a 40 feet width for equipment maneuverability near the shore line and 500 feet accessibility lengthwise at $3,075/acre (RS Means 2001); surveying costs are estimated at $1,673/ acre (R S Means 2001), covering twice the access area.

- Earth work costs: these include mobilization, excavation, and hauling, etc., along a water front width, with a 500-foot inland length; backfill with structural sand and gravel (backfill structural based on using a 200 HP bulldozer, 300-foot haul, sand and gravel; unit earthwork cost is $395/ cu yd (R S Means 2001)
- Paving and surfacing, using concrete 10" thick; assuming a need for a 20-foot wide and 2-foot long equipment staging area at a unit cost of $33.5/ sq yd (R S Means 2001)
- Structural cost is calculated @ $1250/CY (R S Means 2001),assuming two wing walls 1.5 feet thick and 26 feet high, with 10 feet above ground level, and 36 feet long with 16 feet onshore (these walls are for tying in the connecting sheet pile walls).
- Sheet piling, steel, no wales, 38 psf, left in place; these are assumed to have a width twice the width of the screens + 20 feet, with onshore construction distance, and be 30 feet deep, at $24.5/ sq ft (R S Means 2001).

Design Assumptions - Offshore Components

- Structure width is 20% greater than total screen width and 20 ft front to back
- Structural support consists of the equivalent of four 3-foot by 3-foot reinforced concrete columns at $935/ cu yd (R S Means 2001) plus two additional columns for each additional screen well (a 2-foot wide screen assumes an equivalent of 2-foot by 2 feet columns)
- Overall structure height is equal to the well depth plus 10%
- The elevated concrete deck is 1.5 ft thick at $42/ cu yd (R S Means 2001)
- Dredging mobilization is $9,925 if total screen width is greater than 10 feet; is $25,890 if total screen width is 10 feet to 25 feet; and is $52,500 if total screen width is greater than 25 ft (R S Means 2001)
- The cost of dredging in the offshore work area is $23/cu yd to a depth of 10 feet
- The cost of the temporary coffer dam for the structure is $22.5/ sq ft (R S Means 2001), with total length equal to the structure perimeter times a factor of 1.5 and the height equal to 1.3 times well depth.

Field Project Personnel Not Included in Unit Costs:

- Project Field Manager at $2,525 per week (R S Means 2001)
- Project Field Superintendent at $2,375 per week (R S Means 2001)
- Project Field Clerk at $440 per week (R S Means 2001).

The above cost components were estimated and summed and the costs were expanded using the following cost factors.

Add-on and Indirect Costs:

- Construction Management is 4.5% of direct costs
- Engineering and Architectural fees for new construction is 17% of direct costs
- Contingency is 10% of direct costs
- Overhead and profit is 15% of direct costs

- Permits are 2% of direct costs
- Metalwork is 5% of direct costs
- Performance bond is 2.5% of direct costs
- Insurance is 1.5% of direct costs.

Table 2-30 presents the total capital costs for various screen well depths and total screen widths. No distinction was made between freshwater and brackish or saltwater environments. Figure 13 plots the data in Table 2-30 and presents the best-fit cost equations. The shape of these curves indicates a need for separate equations for structures with widths less than and greater than 10 feet. In general, however, the Phase II compliance applications of this technology option included only new structures greater than 10 feet wide.

Table 2-30
Total Capital Costs for Adding New Larger Intake Screen Well Structure in Front of Existing Shoreline Intake

Screen Width	2	5	10	20	30	40	50	60	70	84	98	112	126	140
Depth (Ft)														
10	$280,000	$320,000	$880,000	$1,010,000	$1,220,000	$1,370,000	$1,520,000	$1,680,000	$1,850,000	$2,080,000	$2,330,000	$2,590,000	$2,860,000	$3,140,000
25	$540,000	$600,000	$1,880,000	$2,090,000	$2,390,000	$2,620,000	$2,860,000	$3,100,000	$3,350,000	$3,700,000	$4,070,000	$4,440,000	$4,830,000	$5,230,000
50	$1,130,000	$1,240,000	$4,190,000	$4,570,000	$5,030,000	$5,420,000	$5,820,000	$6,230,000	$6,650,000	$7,240,000	$7,840,000	$8,640,000	$9,090,000	$9,740,000
75	$1,770,000	$1,920,000	$6,650,000	$7,190,000	$7,810,000	$8,370,000	$8,940,000	$9,510,000	$10,090,000	$10,920,000	$11,760,000	$12,610,000	$13,480,000	$14,360,000
100	$2,480,000	$2,690,000	$9,420,000	$10,130,000	$10,930,000	$11,660,000	$12,400,000	$13,150,000	$13,900,000	$14,970,000	$16,060,000	$17,160,000	$18,280,000	$19,410,000

O&M Costs

No separate O&M costs were derived for the structure itself since the majority of the O&M activities are covered in the O&M costs for the traveling screens to be installed in the new structure.

Construction Downtime

As described above, this scenario is modeled after an option described in a 316b Demonstration Study for the Salem Nuclear Plant (PSE&G 2001). In that scenario which applies to a very large nuclear facility, the existing intake continues to operate during the construction of the offshore intake structure inside the sheet pile cofferdam. Upon completion of the offshore structure and removal of the cofferdam, the final phase on the construction requires the shut down of the generating units for the placement of the sheet pile end walls. The feasibility study states that units 1 and 2 would be required to shut down for one month each. Based on this estimate and the size of the Salem facility (average daily flow of over 2 million gpm), EPA has concluded that a construction downtime estimate in the range of 6 to 8 weeks is reasonable. EPA did not select a single downtime for all facilities installing an offshore structure. Instead, EPA applied a six- to eight-week downtime duration based on variations in project size, using design flow as a measure of size. EPA assumed a downtime of six weeks for facilities with intake flow volumes of less than 400,000 gpm; seven weeks for facilities with intake flow volumes greater than 400,000 gpm but less than 800,000 gpm; and eight weeks for facilities with intake flow volumes greater than 800,000 gpm.

Application

The input value for the cost equation is the screen well depth and the total screen width (see Section 2.1 for a discussion of the methodology for determining the screen well depth). The width of the new larger screen well intake structure was based on the design flow, and an assumed through-screen velocity of 1.0 fps and a percent open area of 68%. The same well depth and width values are used for estimating the costs of new screen equipment for the new structure. New screen equipment consisted of fine mesh traveling screens with fish handling and return system (Scenario C).

Figure 13
Total Capital Costs of New Larger Intake Structure