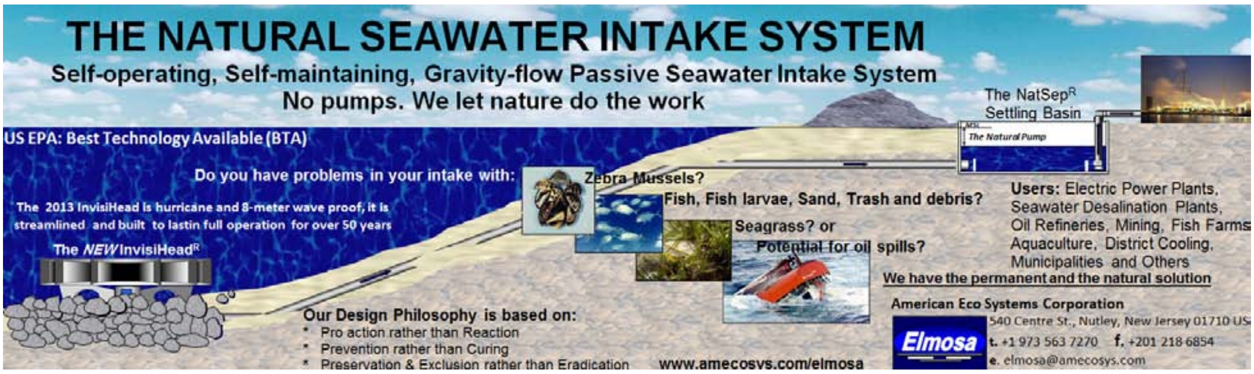
Comparison between the InvisiHead and wedge-wire screen systems performance and stability as well durability and economics

The use of the InvisiHead technology has proved to be more cost-effective than other existing technologies. Especially after adding the latest 2012 improvement to be more selective, the InvisiHead is solidifying its position as the best technology available in the seawater business. ‘The InvisiHead technology represents an example of a high performance velocity cap technology’ concluded a US EPA consultant in his search in 2002 for a system that would have the least adverse impact on the marine environment.

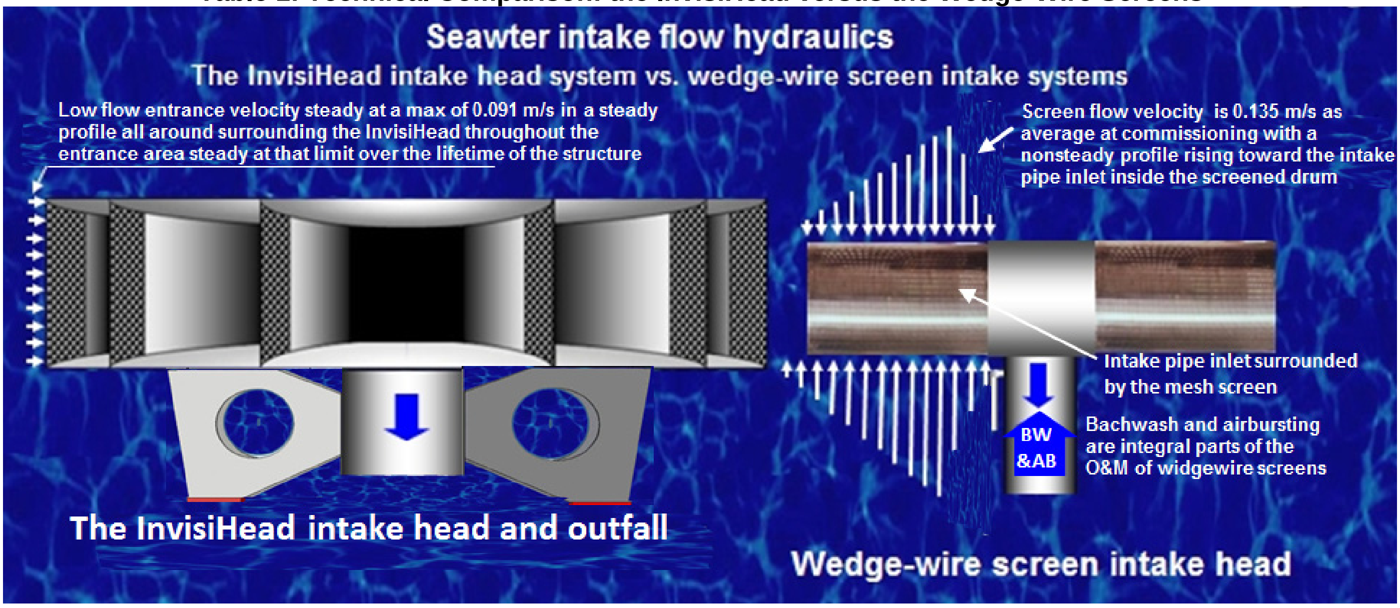
The InvisiHead is a well-engineered proactive intake system which actively addresses operation requirements as well as complying with environmental codes compared to the highly reactive wedge-wire screen intake system. The overall performance of the American Eco Systems Elmosa Seawater Intake and Outfall System is better and higher than any other systems operating in the water intake industry including wedge-wire screens. The system entirely utilizes the natural process in its entire operation from the start to the end – from the point where the first water molecule at the offshore end of the system is drawn to the downstream end of the NatSep onshre where that molecule is transferred to the seawater pump intake. The molecule is gently drawn to the InvisiHead and smoothly guided through all the way to the pump intake at the onshore NatSep intake basin. This high degree of performance is also demonstrated when the InvisiHead operates as a marine outfall.

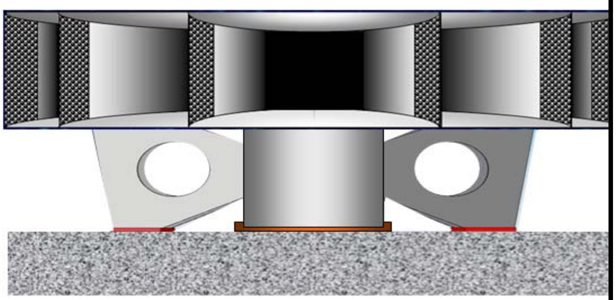
In contrast, the wedge-wire screen intake employs several reactive layers of measures needed to keep the system in operation. Wedge-wire screens are not a dedicated open seawater intake system like the InvisiHead but modified well screens. They have to be supported by a costly cleanup system to keep them in operation. They cannot be used as effluent outfalls however.

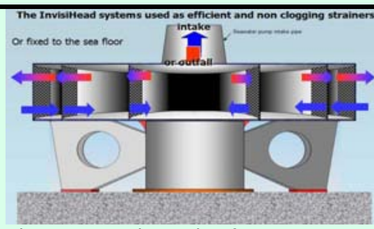
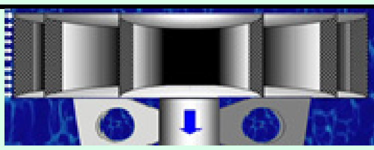
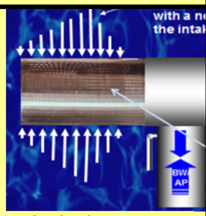


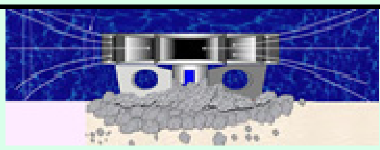
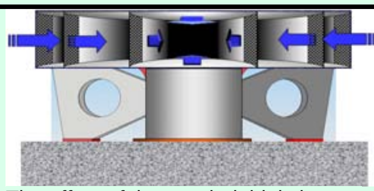
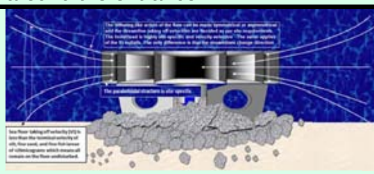
The InvisiHead is improved and made to be more robust to remain stable during hurricanes and voilent weather. It maintains full operation to supply the design capacity under all weather conditions.

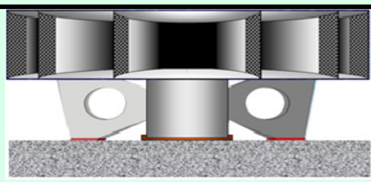
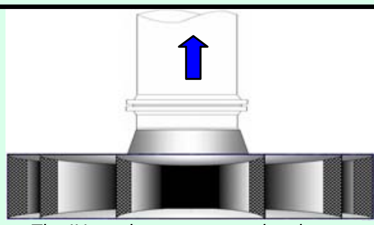
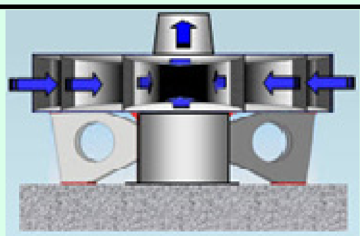
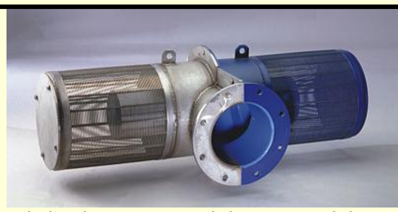
Table 1: Technical Comparison: the InvisiHead versus the Wedge-Wire Screens

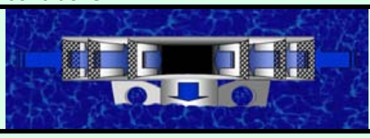
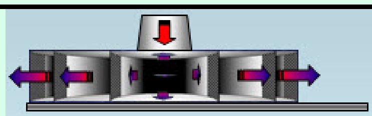
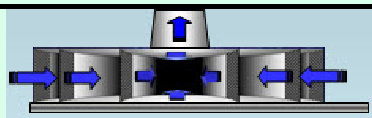
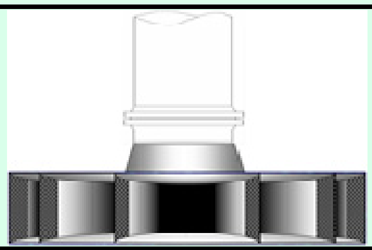


		Seawater Intake Head Type			
		The InvisiHead		Wedge-wire screens	
				 	
SN	Parameter	Description	Comment	Description	Comment
1	Technology type	Stealth, invisible, and cannot be detected by debris, sediments, fish and other marine life. Unlike wedge wire screens, the technology is dedicatedly conceived, designed and streamlined solely for use in water intake and discharge purposes.	The InvisiHead hides and disappears in the ambient. It acts as a super weak sink with an overall head loss less than 0.00017 m at max flowrate. The negligibly weak suction force acting at the entrance area rabidly drops and approaches zero a few centimeters away from the InvisiHead-ambient interface boundary.	A groundwater well modified technology, is highly visible to marine life and sediments in marine environment and attracts and sucks debris, sediments, fish and other marine life.	The modified water well screens act as strong sink where suction rises progressively in reaction to increasing rate of impingement of debris and marine life on the screen surface plugging slots and reducing the flow passage area until total flow blockage is reached. Screen may collapse if head loss exceeds 5 meters. To keep the system in operation and prevent screen damage, the industry had to include measures needed to keep the system in operation like backwash, airburst, and frequent manual cleaning to keep screens fully open.
2	Flow regime	Transitional steady and uniform, the flow goes through 4-phased sequential flow process smoothly transferring from one phase to the next	Flow velocity never goes over 0.091 m/s under all operation conditions over the life time of the structure.	None uniform, velocity is not steady and varies over the screen surface	When quoting, screen manufacturers give average entrance velocity that shows to be lower than the US EPA Rule 16 (b) limit of 0.15 m/s. This means there are parts of the screen surface where the velocity is higher than the average one quoted which may go over the max limit allowed.
3	Environmental	Environmentally	Preserves biodiversity and protects	Screens, by nature,	There is a good potential for marine life

		conceived to blend with the ambient and achieve environmental integration while promoting biodiversity	the ecosystem	tend to adversely impact marine life 	impingement. Juvenile and adult fish fatality is common due to suction forces that pull in on fish against the screen body and trap them on the screen surface. Velocity rises with time until reaching a preset limit when air purging is activated to push debris away from the screen surfaces.
4	Structural stability	Robust heavy duty structure, suction is constant and negligibly low.	 The structure is made of 4-15 mm thick duplex or stainless steel plates. No corrosion impact is anticipated during the system's life (over 50 yrs.) The structure is braced and anchored to a heavy concrete block buried in the seafloor via 1"-thick support legs and stainless steel bolts. Suction is self-controlled and maintained below a negligibly low 0.00002 Bar at all times and under all operation conditions. The system is stable and never fails to deliver the required flow capacity.	V-wire may become vulnerable to corrosion and structural damage. Cyclic suction may cause structural fatigue. Screen may fail if the design hydrostatic pressure limit is exceeded in case of debris purging failure.	 The steel wire making up the screens is relatively thin and can corrode down the road. Standard screens may collapse when water level at the intake basin onshore drops 5 meters below seawater level due to excessive suction. Pressure drop monitoring and automatic control is vital to keep the system in operation. Automation has to be added to activate backwash and airburst mechanisms to unplug flow slots and let the seawater pass. In case automation or air supply equipment fails the screens may collapse.
	Technical Performance				
5	Entrance Velocity	0.091 m/s maximum, steady and constant throughout over the more than 5 decade life time of the InvisiHead structure that safely anchord to the sea floor via rigid and stable support legs	This velocity meets and exceeds the strictest environmental requirements anywhere in the world, but if lower velocities are required, it is practical to achieve that. It meets and exceeds the US EPA Rule 316b requirements (0.15 m/s). Velocity rapidly drops to 0.03 m/s a meter away from the entrance and approaches zero 5 meters away. The sea floor streamlines take off at less than 0.002 m/s – a velocity smaller than the silt grain terminal velocity.	Much higher than 0.091 m/sec variable and rising. It averages 0.135 m/s (very close to the US EPA limit of 0.15 m/s) when new and begins to rise soon after system goes into operation. There are zones on the screen surface where velocity is higher than 0.135 m/s.	 To reduce frequency of air purging and chances for debris and marine life to impinge on the screen surface, entrance velocity has to be reduced to lower than 0.091 m/s – a goal that can never be achieved. To operate at steady velocity of or below 0.091 m/s becomes practically unattainable in screen system.
6	Velocity profile	The distribution of the velocity over the entrance area.	 Flat, low, and steady throughout the entrance eliminating local eddies, and drastically reducing pressure drop. The head loss at the InvisiHead is negligibly low at 0.00017 m.	 Velocity increases toward the intake pipe inlet and non-steady over the screen surface; local suction spots and strips cause debris and marine life to impinge and be trapped on the outer surface, force eggs and larvae through the slots, raise head loss and increase pressure	 Non uniform entrance velocity profile. Velocity goes higher closer to the intake pipe inlet. It is higher at the bottom than any other point over the screen cylinder. Places of higher velocity attract debris, sediment, and marine life and become the first to get blocked. Blockage progressively moves upstream from the inlet, entrance velocities keep increasing while pressure continues to drop until the backwash and air purging systems

				drop, generate higher suction and create a turbulent environment around the entrance area of water rushing into the still remaining open slots. Water level drops onshore	located onshore are activated. Operators usually set the 0.15 m/s max limit as the point at which air purging is activated. Bottom portions of the screen cleaned better because of the higher velocity. Most of the impinging material but not all of it gets purged by the backwash air and is pushed away from the screen region. Shells tend to stick to the top portion where flow velocities are lower. Since the the backwashed and purged material is not drained away, most of it comes back into the screens combined with extra fresh load shortly after purging goes off.
7	Flow Pattern	Omni-directional, paraboloidally funneling in. The IH top and bottom parabolic-shaped structure could have unsymmetrical design if velocity profile need be controlled so as to respond to site conditions, match site requirements while maintaining environmental compliance	 The paraboloidal flow path smoothly guides in water moving in super slow non seafloor-material disturbing velocities. The InvisiHead is site-sensitive and can be customized and tailored during the design and fabrications phases to perfectly fit site requirements and be an integral part of the community	Random nonspecific, insensitive, indifferent, variable, and turbulent.	 No measures are made anywhere in the system to have a measured and well controlled according to how flow patterns. Patterns change and fluctuate allowing debris and marine life to be drawn in and accumulate over the screen surface while some may get sucked in inside the intake pipe system. The system is not site specific
8	Flow Domain	3-D Continuous steady contraction in the case of seawater withdrawal (the intake) and steady continuous expansion in case of effluent discharge (outfall) over the system's lifetime.	 The effect of the paraboloidal shape of the entrance extends outwards into the ambient and rapidly disappears within the vicinity of the structure limiting main flow activity to remain within the few centimeters around the entrance.	Non-specific and defined.	The flow domain is influenced by the changing status of the screen surface porosity and transmissivity. The flow domain is patched and flow continuity is broken in the space surrounding the screens. Slots cannot be maintained all open at all times to define a specific regime or a pattern of the flow.
9	Flow Streamline bundling structure	The flow streamlines curve upwards at the upper portion of the flow bundle, move in straight lines in the mid flow bundle portion, and curve downwards at the lower portion. The velocities of the streamlines taking off from the seafloor remain below 0.002 m/s or lower than the terminal velocity of silt so as not to transport fine sediments into the intake system. The weights of fish eggs, larvae, seaweed and debris are much higher than that of a silt grains, and therefore they remain on the seafloor undisturbed.	 Environments for streamline behavior are decided during the design phase to fit local site conditions and client's requirements. Since the InvisiHead intake and outfall systems are site-specific, flow symmetry is decided as per the local site conditions. The infusing-like action of the flow can be made symmetrical or asymmetrical as per site requirements. The flow streamlines respond to the flaring-in entrance in a matching continuity simulating the physical expansion to extend way beyond the physical boundaries of the structure. The top skin of the flow streamlines curves upwards in response to the upper parabolic inlet plate to prevent sucking in plankton layers near the surface and gradually flattens out towards the middle, straightens at the middle, and curves downward at the	Scattered and turbulent.	Streamlines shift, compress, and lose numbers as flow progresses causing velocity to rise and pressure to drop and impingement rate to intensify. The process continues until the low pressure drop threshold is crossed at which time backwash and air purge sensors and mechanisms are activated. System lacks flexibility to tailor-design screens to be site-specific.

			bottom. The taking off point positions at the bottom and top are decided in the design phase so as to fit site condition requirements.		
	Operation and maintenance				
10		Movement and transport of flow	Self-operating and maintaining for its lifetime. No manual or mechanical or any external interference or any kind of automation is required to keep the system in full and uninterrupted operation for its lifetime.	Movement and transport of flow	Air purging, mechanical and manual interference are required to keep the system operating satisfactorily. Diver services are used for periodical screen cleanup operations.
	Durability				
11		Structural integrity is preserved for a lifetime.	 The system is made of thick stainless or composite steel 4-15 mm thick plates, little welding is involved. Structure is robust and heavy duty and may last way beyond 50 years before structural integrity is compromised if ever.	System is made of weld-intensive thin steel wire.	 Due to the thin sections involved especially the v-wire and because intensive welding is involved corrosion could become a problem and may hinder system operation down the road.
	Site-specifity, sensitivity and O&M flexibility				
12		The ability to respond to local site conditions and to comply with regulatory requirements and client's specifications.	 *The IH used as a pump strainer in an offshore oil platform* The InvisiHead is highly site-specific and can be tuned to respond to site conditions and application requirements and is tailored accordingly. It can be tailored to fit offshore sites like jetties, platforms and LPG and LNG terminals.	Non-site specific.	Hairy sea weeds prove to be deadly to intake screens. They render system operation and maintenance useless. Hairy weeds twist and tangle around the wedge wire. Backwash and air purging become ineffective. Mechanical or manual cleaning becomes costly. Screen replacement becomes more viable.
	Pressure distribution				
13		Flow entering the intake head faces negligible friction losses.	 Uniform at the line of entry- no eddies; head loss is negligibly small at 0.00017 meters. The overall pressure drop is negligibly low at less than 0.00002 Bar.	The head loss starts relatively high at the screen slots increases as the flow progresses.	 Friction increases and rises toward the screen-pipe interface due to the higher velocity, suction is highest at the interface, and impingement starts first at the interface and the blockage progresses toward the upstream end of the screen. Bottom section gets blocked first. blockage intensifies and progresses toward the end until backwash and air purging mechanisms are activated when most of the available head is lost. Head loss is considerably high and becomes

					an important design parameter.
	Capacity delivered				
14		The design flowrate required to keep the plant in full operation	 The design capacity is delivered in full under all operation conditions for the life time of the structure. Operation unhindered at all times regardless of the local site or weather conditions.	The design flowrate required to keep the plant in full operation plus extra water needed for the backwash operation and screen flushing	Constant computerized monitoring is maintained to control pressure drop at the screens offshore and water level drop at the onshore intake-pump basin. Readiness of air compressors and backwash pumps must be maintained to periodically, in most often cases in increased frequencies, flush debris off the screen surface.
	Environmental Performance				
15	Fish eggs and larvae	Most often they remain on the seafloor in spawning areas	The seafloor taking off streamlines' velocity is much lower than the terminal velocities of the creatures' eggs and larvae, and therefore they remain at their habitat undisturbed		The streamline velocities are most often much higher than the terminal velocities of fish eggs and larvae and other creatures like juvenile fish, and therefore, these end up impinging on the screens. The mortality rate increases with the increase of vacuum around the screens.
	Entrainment				
16	Entrainment mortality losses	Finer eggs and larvae may be found in suspension	Any eggs and larvae found in suspension due to local currents that move into the InvisiHead are swept through and out of it through the opposite side ending up at the ambient away from the intake system.	Entrainment rate is proportional to the slot width. All egg and larval sizes, most of juvenile fish entrain. Eggs and larvae grow into shells sticking to the inside surface at stagnant and low velocity regions inside the screen drum.	 Due to high approach and entrance flow velocities, and to high vacuum created at the screen slots, impingement of marine life is high and so is the mortality rate.
17	Sediment and debris	Negligible		High	
18	Bottom Sediment Disturbance	Negligible		High	
19	Fouling	None if the built-in disinfectant-dispersing system is included, if not, marine growth does not impact or hinder system operation		Screens are easily fouled	Marine growth and biofouling can become heavy in screen intakes inside and outside.
	Operation and maintenance equipment				
20	Seawater intake pumps	Yes		Yes	
	Trash racks	None		Yes	

21	Traveling screens and filters	None		Yes	
22	Intake basin backwash screen pumps	None		Yes	
23	Offshore intake screens	None		Yes	
24	Offshore screen backwash pumps	None		Yes	
25	Basin screen backwash blowers	None		Yes	
26	Backwash equalizing basin blowers	None		Yes	
27	Air purging pumps	None		Yes	
28	Air compressors	None		Yes	
29	Automation	None		Heavy	
30	sensors	None		Numerous	To sense pressure drop, level drop, etc, activate backwash pumps, airburst systems and compressors, etc.
	Intake Head Features				
31	Flow movement	Low approach velocity 0.002 m/sec max at 5 meters away.		Non-specific	
32	Entrance velocity	Slow and smooth at 0.091 m/s max		Turbulent at >0.091 m/s	
33	Approach of flow @ 5 m away and beyond	Less than 0.002 m/s decays to 0 m/s a short distance further.		Much higher than 0.002, patchy and unpredictable	
34	Head loss	<0.00017 m		Rises close to the available operating head and if not debris frequently flushed off, total blockage could take place.	
35	Flow phases	4 sequential, progressive transitional providing self-cleansing and self-maintaining and self-operating mechanisms for the system.	Human or mechanical interference is unnecessary over the lifetime of the system	External interference and human controlled operation and maintenance are a major factor required to keep the system in operation.	
36	External interference	None		Is an integral part to keep water flowing	
37	Intake pipe sizes	smaller		larger	
38	Basin	shallower		deeper	
39	Pumping energy	low		Much higher	
40	anti biofouling chemical dispensing system	Built-in and sprayed over 360° of the system		-	
41	Backwash	Not needed and not implemented.		Debris and organisms back-flushed from the screens would re-impinge on the screens following the back-flush cycle.	

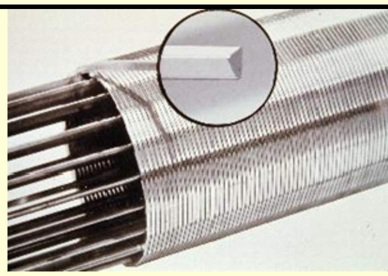
42	Operation & maintenance	None		Required	
43	Use as effluent outfall	Works as a high performance brine, coolant, and municipal and industrial discharging diffuser outfall.		N/a	
44	Compliance with the US EPA 316(b) 0.15 m/s entrance intake velocity or less	Meets and exceed this standard and other international standards @ 0.091 m/s or less.		It is very difficult for the system to practically comply with this EPA standard	
43	Loss of service	0% of the time		It is the time required for backwash, air purging and frequent maintenance – a good portion of the time is used in system shut down for maintenance. System can go out of service if any component of the purging system fails.	
44	Overall intake system reliability and stability	Highly reliable and stable, heavy duty, and robust, keeps operating under all environmental and weather conditions nonstop of over 50 years.		Can be overwhelmed by the sudden presence of large loads of debris including marine life, sediments and debris that would lead to system shutdown especially during stormy conditions and in hurricane-active locations.	 The structural integrity of thin-wired screens may become vulnerable under severe condition.

Table 2: Cost comparison between the InvisiHead and the Wedge-Wire Screen Intakes

SN	Parameter	InvisiHead	Wedge-wire screen intake
1	**Costs per installed cubic meter per hour**	**$270 for smaller systems to $66 for larger ones**	**$1112 for smaller systems to $198 for larger ones**
2	Costs of the Seawater intake pumps installed in the onshore intake basin	To cover costs of pumps required to pump 100% of the plant capacity.	To cover pumps required to pump 100% of the plant capacity plus backwash and flushing water quantities.
3	Costs to cover backwash screen pumps	No costs are involved since no backwash is required.	Added since back wash is an integral part of the system.
4	basin screen backwash blowers	No costs are involved since no basin screen backwash is required.	Added since back wash is an integral part of the system
5	Costs to cover offshore screen backwash pumps	No costs involved since no offshore screen backwash is required.	Added since back wash is an integral part of the system.
6	Air compressors, air purging	No costs are involved since no air purging is required.	Added since air purging is an integral part of the system.
7	Backwash equalizing basin blowers	No costs are involved since no screens are required.	Added since screening is an integral part of the system
8	Offshore screen	No costs are involved since no offshore screens are required.	Added since screening is an integral part of the system.

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9	Trash racks	No costs are involved since no screening is required.	Added since screening is an integral part of the system.
10	Traveling screens	No costs are involved since no screening is required.	Added since screening is an integral part of the system.
11	Costs of the complete Elmosa offshore sweater intake system	They include the costs of the offshore portion (the passive InvisiHead) the pipeline, the passive onshore intake basin, and the seawater pumps. The pipeline costs are less due to the smaller pipes required for the operation. The costs of the intake basin are less due to its smaller size. The costs of seawater pumps are less due to the lesser capacity required for system operation.	The costs of the wedge wire screen intake system include the costs of the active wedge wire screen intake head, the pipelines, and the screening and filtration equipment installed in the onshore intake basin. Extra costs are required for a larger pipeline, a large intake basin, and backwash, flushing, and air purging equipment including compressors and pumps, and computer monitoring systems to operate the backwash and cleanup systems when pressure drop threshold is reached.
12	Energy costs	The only costs involved are those involved with the seawater intake pump operation	Higher costs are involved in the operation of the seawater intake pumps, backwash and flushing pumps, blowers, compressors, etc.
13	**Capital cost**	**Ranges between $85,000 for a 2 MGD seawater intake capacity to $3,000,000 for a 290 MGD capacity**	**Ranges between $350,000 for a 2 MGD seawater intake capacity to $9,000,000 for a 290 MGD capacity**
14	**Overall operation & maintenance costs, annually**	**0 costs**	**Ranges between $42,000 for a 2 MGD system to $100,000 for a 290 MGD**
15	**Investment payback period**	**Taking into account how much the utility would spend on O&M, the InvisiHead systems pays back the money invested in purchasing it in 2 years in case of the 2 MGD capacity and about 30 years for the 290 MGD capacity in the form of saving the money that would be spent in covering the costs of operation and maintenance for wedge wire screens. We should keep in mind the savings made in capital investment. $265,000 would be saved in case of the smaller capacity and $6,000,000 in the larger on if the InvisiHead is used instead of the wedge wire screens.**	**N/A**

InvisiHead Cost Effectiveness

If we take a 500 MW coal-fired power plant that uses wedge screens to supply cooling water to the plant as an example, the total annual O&M costs are about $80,000/year. The amount can be saved by using the O&M-free InvisiHead system.

For a 2 mgd capacity the estimated total capital cost of a wedge wire intake screen system would be approximately $350,000, $320,000 and $310,000 for 0.5 ,1.0 and 2.0-mm slot size wedge-wire screens with a hydroburst system, respectively. The estimated annual O&M costs would be around $42,000 for the 0.5, 1.0, and 2.0-mm slot size wedge-wire screens with a hydroburst system.

For a large capacity of a 290 MGD, the capital costs are about $9,000,000 for the 1.0-mm wedge-wire screen.

On the other hand, the duplex steel InvisiHead capital costs are about $85,000 for the 2 MGD and $3,000,000 for the 290 MGD capacity.

$42,000 a year for the 2 MGD and $80,000 for the 290 MGD that would otherwise be spent as O&M expenses in wedge wire screens will be saved if the case of using the InvisiHead.

The smaller capacity InvisiHead is made of a 6-mm thick duplex steel plate while the larger one is made of 12-mm thick plate. Useful life of the InvisiHead structure is 50+.