City of Bellingham Screen House: Evaluation of Alternative Screening Approaches (Task 3.10.3)

PREPARED FOR:	City of Bellingham Project Team
PREPARED BY:	CH2M HILL Project Team
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1. Introduction

The City of Bellingham (City) is underway with evaluating alternative approaches for rehabilitating three corroded 48-inch diameter steel pipes in the lower level of the City's Screen House. Previous evaluation of these sections of corroded pipe indicate that rehabilitation should be implemented as soon as reasonably possible. The City has made pursuit of this rehabilitation a high priority.

As part of this rehabilitation effort, the City recently undertook a condition assessment of the entire Screen House to confirm its continuing suitability as a screening structure before committing funds to the pipe-rehabilitation effort. This condition assessment and discussion regarding rehabilitation of the corroded pipes, as well as other aspects of the Screen House facility that warrant rehabilitation, is presented in the

July 22, 2014 DRAFT technical memorandum entitled “City of Bellingham Screen House: Condition Assessment and Improvement Report.”

In recognition of the challenge and cost associated with rehabilitation of the existing Screen House, the City initiated evaluating alternative approaches to screening the flow stream from Lake Whatcom and segregating this flow stream to its municipal supply that is conveyed to its Whatcom Falls Water Treatment Plant (WTP) and its industrial supply that is conveyed to the City’s waterfront. The objective of this effort is to determine whether or not there are would be more cost-effective alternatives that provide greater benefit than simply rehabilitating the existing Screen House.

Development of several alternative approaches is presented herein. These alternative approaches, and the Screen House rehabilitation approach presented in the July 22, 2014 DRAFT memorandum, will be evaluated by the City to select the approach to be implemented.

2. Applicable Fish Screening Requirements

Applicable fish screening requirements for existing systems that predate fish screening requirements are presented herein along with the requirements for new fish screening facilities.

2.1 Current Condition

Applicable regulatory requirements depend on the context of the particular fish screening situation. In this case, the City is considering improvements to its existing water supply system that includes an intake and screening. It is also considering alternative facilities that are anticipated to require fish screening features that are compliant with current applicable fish guarding requirements.

The City’s existing 72-inch diameter wood stave intake pipeline in Lake Whatcom is equipped with a timber crib barrier at a depth of 30 feet, approximately 900 feet offshore. This barrier keeps large debris from entering the intake pipeline. The City’s Screen House, located approximately 7,600 feet from the Lake, houses two traveling screens. The screens have provided reliable and effective screening protection of the downstream municipal water treatment and industrial processes for many decades. The traveling screens were installed to keep smaller debris and fish from Lake Whatcom from entering the downstream municipal and industrial water systems. While they have effectively served these purposes, these same screens do not comply with current state and federal regulatory requirements for fish protection.

2.2 State and Federal Applicability

Per the Revised Code of Washington (RCW) 77.57.010, fish guard devices are required on all intakes and diversions from lakes and rivers. Fish guard devices are often screens but can be other devices and structures, such as behavioral barriers, if such devices are demonstrated to be applicable and effective.

The original construction of the City’s intake system, including the Screen House and wood stave intake pipeline, pre-dated fish screening regulatory requirements in the State of Washington. Per RCW 77.57.070, structures constructed and operating before June, 11 1947 are essentially “grandfathered” and deemed not to be in violation of current fish protection requirements. However, major modifications or upgrades to an existing facility could constitute a changed condition that would trigger fish protection requirements. While this eventuality is not anticipated as it relates to rehabilitating the Screen House, pro-active consultation with Washington State Department of Fish and Wildlife (WDFW) provide clarification.

It is anticipated that rehabilitation of portions of the existing water supply system, including the Screen House, would not trigger the fish protection regulatory requirement. However, if the decision were made to replace the existing Screen House with a new facility or to change the existing point of diversion, it is believed that current fish protection standards per RCW 77.57.010 would be required by WDFW. Direct consultation with the WDFW would be necessary to confirm WDFW's view in this instance and to obtain clear direction for how the City should proceed.

It is anticipated that WDFW has primary jurisdiction for fish protection in Lake Whatcom. A similar federal requirement (Section 7 of the Endangered Species Act [ESA]) for fish guard devices involving the National Marine Fisheries Service (NMFS) and/or the United States Fish and Wildlife Service (USFWS) applies if threatened, endangered or anadromous fish species are present. However, in this case, because there are no threatened, endangered, or anadromous fish species in Lake Whatcom, it is assumed that the ESA Section 7 requirement does not apply. The state design criteria is similar to the NMFS design criteria but it is assumed that only the appropriate WDFW requirements would apply.

3. Description of Alternative Screening Approaches

The alternative screening approaches presented herein were developed to enable abandonment of the existing Screen House facility and replacement with a new screening facility that is compliant with current fish screening requirements.

3.1 Initial Consideration of Alternatives

Five fish protection approaches were considered for development as alternatives to rehabilitating the existing Screen House. Each of these alternatives involve abandoning the existing Screen House facility and bypassing the Screen House facility with a pipeline system that carries the full capacity of the City's instantaneous water right from Lake Whatcom of 82 million gallons per day (mgd). The five alternatives are presented in Table 3-1 and their locations are shown in Figure 1.

After initial consideration, Alternatives 4 and 5, listed in Table 3-1, were eliminated from further development and evaluation. These two alternatives include new screening facilities at the Screen House site and the WTP, respectively. These alternatives were eliminated because they do not comply with the requirements for fish protection in conformance with RCW 77.57.010 and 77.57.070 that specify that fish protection facilities keep fish from entering the intake and/or enable fish to safely return to the originating water body (Lake Whatcom). Therefore, it was assumed these alternatives would not be approved by WDFW.

The three alternatives carried forward for development, as described in the sections below, include:

1. In-Lake Cylindrical Screens
2. In-Lake Velocity Cap
3. Gate House Site Screening

These alternatives each comply with the fish protection requirements cited above, or in the case of Alternative 2, could potentially be approved by WDFW on a site-specific basis.

TABLE 3-1
Summary of Alternative Screening Approaches Initially Considered

	Alternative	Description	Advantages	Disadvantages
1	In-Lake Cylindrical Screens	Two 72-inch cylindrical screens with mechanical brush cleaning.	• Low initial capital cost. • High level of fish protection.	• Requires diving subcontractor involvement for O&M, resulting in higher cost.
2	In-Lake Velocity Cap	Static device that creates velocity vectors that fish avoid.	• Low initial capital cost. • Minimal O&M required.	• Requires diving subcontractor involvement for O&M, resulting in higher cost. • Doesn't provide debris screening. • Lower level of fish protection. • Requires additional regulatory approval.
3	Gate House Site Screening	New screening facility on shore of Lake Whatcom adjacent to exiting Gate House.	• High level of fish protection. • Compliant with WDFW requirements.	• High cost. • Complex construction staging. • Potential permitting and public/stakeholder challenges.
4	Screen House Site Screening	New screening facility and gravity fish return to Whatcom Creek.	• Combines Screen House bypass with new fish protection screen facility.	• Moderate cost • Low level of fish protection due to long transport time. • Would result in reduction of heavily used area of park. • **Fish return not compliant with WDFW requirements.**
5	WTP Site Screening	New screening facility and gravity fish return to Whatcom Creek.	• Consolidates facilities at WTP.	• High cost. • Low level of fish protection due to long transport time. • Minimal space at WTP. • Fish return not compliant with WDFW requirements.

3.2 In-Lake Cylindrical Screens

Alternative 1 (In-Lake Cylindrical Screens) consists of two 72-inch diameter cylindrical screens installed vertically on a manifold located at the end of the existing 72-inch diameter wood stave intake pipeline. The screens would be located approximately 900 feet offshore at a depth of approximately 30 feet (10 feet above the bottom of the lake). The combined total capacity of the cylindrical screens would be 82 mgd. The screens would be cleaned with a mechanical brush system powered by a submersible electric motor. Cylindrical wedgewire screens are common throughout the Pacific Northwest and are able to meet current agency criteria with a slot size of 1.75 mm and an approach velocity of 0.4 feet per second (fps). A photo of a similar screen is presented in Figure 2. Schematic diagrams of the facility are presented in Figures 3 and 4.

The screens would be installed on a 72-inch diameter steel pipe manifold set on piles. This manifold would be structurally separate from the existing wood stave intake pipe. The connection between the manifold and the existing wood stave pipeline would employ a rubber boot seal to ensure flexibility at this location. It is anticipated that construction and pile driving/drilling operations would be supported by a large barge with a crane positioned at the site. The manifold and fish screens could be assembled as a single unit in the dry, but installation and connection to the existing pipeline would require underwater dive work.

The screen brush cleaning mechanism would be activated manually, via a timer or based on a set pressure differential across the screens. Brush screens can be operated using an electric motor or via hydraulic cylinders. An electric system is better suited to this application because of the potential for hydraulic fluid leakage into the lake. Another common cleaning approach is air backwashing. However, in this case, air backwashing would pose a public safety issue and a propeller system was not practical in this size. It is anticipated that underwater dive inspections would be performed on a semi-annual basis.

3.3 In-Lake Velocity Cap

Alternative 2 (In-Lake Velocity Cap) consists of a 26-foot diameter velocity cap installed on an upturned elbow at the end of the existing 72-inch diameter wood stave intake pipeline. A velocity cap is a fabricated steel structure that diffuses the intake flows horizontally in a radial pattern. This elicits a behavioral avoidance response from fish; however due to its configuration, the velocity cap does not provide a physical barrier to fish. Velocity caps are common for deep offshore intakes and may or may not be acceptable to WDFW at this location. The advantage of a velocity cap is that it is relatively inexpensive, it does not require cleaning and it is simple to maintain.

The velocity cap would be located approximately 900 feet offshore at a depth of approximately 30 feet (10 feet above the bottom of the lake). The capacity of the structure would be 82 mgd and the approach velocity would be approximately 0.3 fps. A photo of a velocity cap is provided in Figure 5. A schematic diagram of a velocity cap assembly is presented in Figure 6.

Similar to the cylindrical screen alternative, the velocity cap would be set on a pile-supported pipe structure that would be structurally separate from the existing wood stave intake pipe. The connection between the pipe structure and the existing wood stave pipeline would employ a rubber boot seal to ensure flexibility at this location.

It is anticipated that construction and pile driving/drilling operations would be supported by a large barge with a crane positioned at the site. The velocity cap could be assembled as a single unit in the dry, but installation and connection to the existing pipeline would require underwater dive work.

3.4 Gate House Site Screening

Alternative 3 (Gate House Site Screening) includes the construction of a screening facility incorporating WDFW-compliant fish protection screens. The facility would be located on the City-owned parcel between the existing Gate House and the Lake Whatcom shoreline as shown on Figure 7. The screening facility would be constructed directly on the alignment of the existing wood stave intake pipeline, necessitating a temporary bypass for construction.

The screening facility would consist of an open channel with below-grade concrete walls formed against external sheet pile walls, a concrete floor, and three vertical traveling screens in a parallel configuration. The total capacity would be equivalent to the City's water right of 82 mgd. The screens would include fish protection features such as Ristrop buckets, a spray wash system, and a fish bypass to return fish safely back to the lake. A debris return would also be provided. Each screen bay would have the ability to be isolated from the common plenums with stop logs to enable maintenance and repair. Segregation using slide gates is likely not possible due to hydraulic requirements related to the fish screen, but this issue could be further evaluated during preliminary design if this alternative were to be pursued. Schematic plan and section drawings are presented in Figures 8 and 9.

There are several challenges associated with implementing this alternative, including:

- Permitting and construction requirements related to potential wetland and shoreline impacts.

- A very small site for a relatively large facility with limited space available for construction access, construction staging, and the facility itself.
- Potential for public concern and opposition due to aesthetic impacts to the immediate neighborhood as well as the general public.
- Dewatering requirements associated with high groundwater conditions.
- Need to maintain sufficient bypass flow during construction.

Of these items, the one issue that presents perhaps the greatest challenge is the sequencing of construction activities to ensure uninterrupted flow for municipal and industrial customers downstream. Only a few short-term shut-downs of no greater than 24 to 36 hours would be permitted. The following sequence of key construction activities was developed to confirm that this alternative could be successfully implemented:

1. Install a temporary pumped intake via 36-inch diameter HDPE pipe extended 100 feet into Lake Whatcom with a cylindrical fish screen. Route this temporary bypass into the Gate House wet well after stop logs have been installed in the Gate House. This temporary intake will be used for approximately two weeks and will be supported by a moored barge off-shore.
2. Install a concrete caisson (wet well) located immediately upstream of the proposed fish screen facility and on top of the existing wood stave intake pipeline. Cut the existing wood stave pipeline to incorporate the caisson, which will remain permanently. Caisson installation will require extensive and costly dewatering and filtering of return water.
3. Install the caisson with provisions for a bulkhead for maintaining dry conditions on the downstream side and wet conditions on the upstream side.
4. Initiate bypass pumping from the upstream side of the bulkhead to the Gate House. This can be accomplished by relocating the pumping equipment from the temporary in-lake intake system. Fish screening should not be necessary for this temporary bypass system. This temporary bypass system will remain in operation for the duration of construction, which is anticipated to be 6 to 9 months.
5. Construct the fish screen facility. Extensive dewatering is expected and costly filtering of return water to the lake will be required.
6. Construct fish return bypass back to the lake.
7. Make connections to caisson upstream and Gate House downstream.
8. Remove the bulkhead in the caisson, remove bypass pumping equipment, and begin operations of new facility.

Construction of the fish bypass outfall in Lake Whatcom will likely require in-water work behind a temporary cofferdam. This could be a Portadam (fabric membrane with steel support frame), a crib and bin system filled with gravel, super sacks or similar. The timing of this work would need to be coordinated with permitted in-water work periods, which are typically in the late summer (July through September).

4. Alternative Supply Development

Unlike the alternative screening approaches presented in Section 3, the alternative supply development presented herein does not involve the abandonment and replacement of the existing Screen House. Alternative supply development is a different means of temporarily bypassing the existing Screen House from what is presented in the July 22 DRAFT technical memorandum summarizing the condition assessment of the Screen House. Development of the alternative supply presented herein would be pursued in combination with undertaking repairs at the Screen House and committing to the continued long-term use of the Screen House and the existing supply via the 72-inch diameter wood-stave intake, the Gate House, and the tunnel.

4.1 Description of City's "Old" Supply System

The alternative supply considered herein is the City's supply that was used prior to its existing supply. This older supply was used until approximately 1939. It continues to be used to supply the WDFW fish hatchery directly to the northwest of the Screen House. If it were connected to the existing supply system just downstream of the Screen house it could be used while rehabilitation of the Screen House is underway. This supply and its main component elements are depicted in Figure 10.

This old supply system includes the following key elements:

- A pipeline (partly 30-inch diameter and partly 24-inch diameter) extending from the fish hatchery toward Bloedel Donovan Park.
- A flow-splitting/chlorination facility just downstream of the City's control dam, referred to on old drawings as the "Larson Chlorination Station" or the "Larson Pump Station." It is referred to hereinafter as the "Old Larson Facility." The above-grade portion of this structure has long been removed, leaving only below-grade walls, and portions of an at-grade floor that are in functional but poor condition.
- A 3-foot by 4-foot, brick-lined tunnel extending across Bloedel Donovan Park from the Old Larson Facility.
- A 48-inch diameter wood-stave intake in Lake Whatcom that extends approximately 800 feet into Lake Whatcom, based on a review of old documents.

A review of old drawings of the supply system indicates that it could potentially be connected to the City's current primary supply system via the 66-inch diameter concrete cylinder supply pipeline downstream of the Screen House. The approximate connection location would be 200 feet southwest of the Screen House. Approximately 300 feet of new 24- or 30-inch diameter pipeline would be necessary to connect to this alternative supply at the northeast end of the adjacent WDFW fish hatchery to the 66-inch supply pipeline. New direct-buried butterfly isolation valves would be necessary in the 66-inch diameter pipe and in the 30-inch diameter pipe. Plan and section drawings of the dual-valved, 30-inch by 66-inch connection is presented in Figures 11 and 12.

4.2 Hydraulic Capacity

The hydraulic capacity of this alternative supply was estimated and documentation of that work is presented in the November 7, 2014 technical memorandum entitled: "City of Bellingham Pretreatment Project: Hydraulic Evaluation of Alternatives."

Preliminary hydraulic evaluation of this supply indicates that with 600 feet of new 30-inch diameter pipe connecting to just northeast of the fish hatchery, roughly 11.5mgd would be available to the City's WTP (14.5 mgd combined total to the fish hatchery) at a Lake Whatcom water surface elevation of 314 feet. This flow would be adequate to supply the City with 11.5 mgd during winter while still allowing enough flow for operation of the fish hatchery (3 mgd). These estimated flow capacities are based on completion of this project prior to the planned dissolved air flotation (DAF) facility being placed into service.

If the DAF were in service, there would be a corresponding reduction in capacity of this supply alternative to approximately 13 mgd for the combined total flow (10 mgd to the WTP for City use) because the DAF will be at a higher water surface elevation than the existing raw water mixing chamber of the WTP. However, note that the DAF project will be constructed with a bypass connection that enables it to be bypassed. Doing so would preserve the current hydraulic conditions and allow the higher capacity of this alternative supply. For the purpose of this evaluation, it is presumed the DAF facility would be bypassed during any temporary, short-term use of this alternative supply.

The City's average wintertime water use is approximately 8 mgd. Average use at the WDFW fish hatchery varies throughout the year from between 2 and 3 mgd. Therefore, assuming the WDFW fish hatchery would operate without any disruption, during the time the alternative supply would be implemented for repairs at the Screen House (approximately 1 to 2 months), the combined total flow necessary is 11 mgd (assuming 3 mgd for the hatchery). These water supply requirements can be accommodated by the estimated capacity of this alternative.

4.3 Added Benefit of Alternative Supply

A very important benefit afforded by this alternative is that it provides a potential long-term alternative source of supply to the City's existing supply. It enables bypassing not only the Screen House, but also the existing tunnel, the Gate House, and the 72-inch diameter wood-stave intake. Use of this alternative supply would enable preventive maintenance as well as repair of any of these existing supply facilities, likely extending their continued beneficial for years or even decades. This alternative supply would also be available to enable bypassing the existing supply facilities in the event they are damaged by earthquake or other factors. For example, if the existing tunnel were to be damaged to the point where it needs extensive repairs that could take weeks or months, this alternative supply could be used while repairs are made.

Additionally, the capacity of this system could be increased substantially over time to increase its capacity and value as an emergency backup supply. Replacement of existing 24-inch and 30-inch segments of the pipeline up to the Old Larson Facility could be replaced with larger diameter pipe (e.g., 36-inch diameter). Replacement of this segment of pipe will eventually be necessary, given that is approximately 100 years old, and presumably is in a somewhat deteriorated condition. Greater supply capacity would enable the City to more easily meet its summertime peak water supply needs in the event it needed to use this alternative supply under emergency conditions.

4.4 Next Steps to Confirm Feasibility of Alternative Supply

Preliminary examination of the City's old supply and assessment of its suitability as a temporary alternative while rehabilitation of the Screen House has already included the following:

- Field excavations to determine the location of key elements of the old supply.
- Preliminary hydraulic analysis to confirm the adequacy of the supply system.
- Review of historical WDFW and City wintertime water use.

To assess the feasibility of this alternative supply approach, the following activities are necessary:

- Confirm City's ownership of the facilities that comprise this alternative supply – from Lake Whatcom to the fish hatchery.
- Coordinate with WDFW and confirm hatchery's water use needs. It appears as though water usage rarely exceeds 3 mgd and generally ranges between 2 and 3 mgd.
- Coordinate with WDFW, review prior use agreements (if any) between the City and WDFW with respect to use of the City's old supply facilities. Develop agreements needed for City's use of system on a temporary emergency basis.
- Coordinate with WDFW regarding the compliance status of this supply system with current fish protection requirements.
- If possible, conduct actual flow testing of the existing system to confirm its flow capacity.
- Determine City's property rights associated with each of the component elements of the supply system.

- Coordinate with the Washington Department of Ecology to determine what water rights adjustments are necessary to make use of the alternative supply.
- Determine the location where the old concrete-encased steel pipeline transitions from 30 inches in diameter to 24 inches in diameter to enable confirmation of the system hydraulic capacity. Preliminary hydraulic analysis (based on a review of available drawings) assumes the existing pipe is 30 inches in diameter to approximately the downstream end of the existing "Derby Pond."
- Determine the condition of these supply facilities and identify improvements needed.

It is understood that evaluation of this alternative supply approach will be undertaken prior to having all of the information necessary to confirm its feasibility for implementation. However, this pro-active evaluation is warranted for two key reasons: 1) Development of this alternative supply provides not only the near-term benefit of enabling rehabilitation of the Screen House, but also the long-term benefit of an emergency, back-up supply; and 2) The corroded pipes in the Screen House must be rehabilitated as soon as possible, and if alternative supply development appears to be a preferred approach based on the forthcoming evaluation process, confirmation of its feasibility must be undertaken as soon as possible.

4.5 "Screen House Rehabilitation Plus Alternative Supply"

As stated above, alternative supply development essentially replaces the Screen House bypass presented in the July 22 DRAFT Screen House condition assessment memorandum. Therefore, the alternative supply development presented herein would be combined with the recommended Screen House improvements presented in Table 5-1 of the DRAFT Screen House condition assessment memorandum to comprise an alternative approach to Screen House rehabilitation. This approach is referred to herein as the "Screen House Rehabilitation Plus Alternative Supply" alternative. A summary of the improvements associated with this alternative are presented in Table 4-1.

TABLE 4-1
Summary of Recommended Improvements for Screen House Rehabilitation Plus Alternative Supply

Improvement Type	Year of Implementation	Comments
Alternative Supply Improvements		
700 linear feet of 30-inch pipeline	2016	The pipeline length is assumed to be 700 feet, but could be different based on location of transition between existing 30-inch and 24-inch segments of old pipeline. New pipe would go under existing canopy shop/parking structure at hatchery.
Upstream Connection to 24/30-inch Pipeline	2016	Once location of transition between 30-inch pipe and 24-inch pipe is established, connection would be to 30-inch section. New connection to fish hatchery would be necessary as well.
Connection to 66-inch Pipeline	2016	This connection would need to be made within a 36-hour timeframe, which is feasible.
Screen House Improvements		
48-inch Diameter Outlet Pipelines	2016	Carbon fiber reinforced plastic liner by specialty contractor.
Structure	2016	Miscellaneous grout patching. Work duration up to two weeks. Painting of Waste Well.
Slide Gates and Mud Valve	2016	Replace 5 of 10 slide gates. Remove (no replacement) 3 of 10 slide gates. Replace mud valve.
Traveling Screens	2034	Replace traveling screens in approximately 20 years.

5. Estimated Costs

Estimated initial capital costs were developed for each of the alternative screening approaches developed and presented in Section 3 as well as the alternative supply development approach presented in Section 4. In addition to these initial capital costs, annual operations and maintenance costs and 40-year life-cycle costs were developed for continued use of the Screen House facility in combination with a 30-inch diameter pipeline bypass (developed and presented in the July 22, 2014 DRAFT Screen House condition assessment technical memorandum). These estimated costs were developed to the "concept level" or "Class 5" level of accuracy as defined by the Association for the Advancement of Cost Engineering International (AACEI). This level of cost estimating is considered accurate to +30 to -20 percent.

These estimated costs were prepared for guidance in evaluating the recommended improvement approach for the Screen House facility based on information available at the time of the estimate. The final cost of the project will depend upon the actual labor and material costs, competitive market conditions, implementation schedule, and other variable factors. As a result, the final project costs will vary from the estimates presented herein. Because of this variation, project feasibility and funding needs must be carefully reviewed prior to making specific financial decisions.

A summary of these estimated capital, operations and maintenance, and life-cycle costs for all five alternatives are presented in Table 5-1. Estimated capital, annual O&M, and life-cycle costs for each of the five alternative screening approaches are presented in Tables 5-2 through 5-6. The following markups are incorporated into the construction costs listed in the tables below:

- Contractor overhead: 10%
- Contractor profit: 6%
- Mobilization/bond/insurance: 10%
- Contingency: 30%

TABLE 5-1
Summary of Estimated Costs for Screening Alternatives

Cost Element	Alternative 1, Screen House Rehabilitation Plus Bypass	Alternative 2, Screen House Rehabilitation Plus Alternative Supply	Alternative 3, In-Lake Cylindrical Screens	Alternative 4, In-Lake Velocity Caps	Alternative 5, Gate House Site Screening
Initial Capital Cost	$3,948,000	$2,913,000	$6,958,000	$6,352,000	$14,932,000
Annualized O&M	$81,000	$81,000	$42,000	$33,000	$106,000
Life Cycle Cost	$5,333,000	$4,298,000	$7,675,000	$6,913,000	$16,750,000

TABLE 5-2

Summary of Estimated Costs – Alternative 1, Screen House Rehabilitation Plus Bypass

Item		Cost
Construction Costs:		
Screen House Improvements		
Slide gates		$551,000
12-inch mud valve		$66,000
Grout repair/concrete patching		$26,000
48-inch pipe repair		$559,000
Screen House bypass		$1,456,000
	CONSTRUCTION SUBTOTAL	**$2,658,000**
Construction w/ Escalation to February 2016 (6.5%)		$2,831,000
Construction w/ Sales Tax (8.7%)		$3,078,000
Non-Construction Costs:		
Permitting Allowance		$100,000
Engineering and Construction Management [1]		$770,000
	CONSTRUCTION TOTAL	**$3,948,000**
Annual O&M		
Annualized Cost of Inspection (every 5 years)		$10,000
Annualized Cost of Major Repair (every 5 years)		$6,000
Annualized Cost of Minor Screen Repair (every 10 years)		$26,000
Annualized Cost of Replacement (after 30 years)		$39,000
	O&M TOTAL	**$81,000**
Life Cycle		**$5,333,000**

Notes:

[1] Engineering and Construction Management costs estimated as 25 percent of construction subtotal with sales tax.

TABLE 5-3

Summary of Estimated Initial Costs – Alternative 2, Screen House Improvements Plus Alternative Supply

Item		Cost
Construction Costs:		
Screen House Improvements		$1,202,000
Alternative Supply		
Upstream connection		$136,000
30-inch pipe		$276,000
Downstream connection		$260,000
	CONSTRUCTION SUBTOTAL	**$1,874,000**
Construction w/ Escalation to February 2016 (6.5%)		$1,996,000
Construction w/ Sales Tax (8.7%)		$2,170,000
Non-Construction Costs:		
Alternative Supply - Additional Study/Evaluation Allowance		$100,000
Permitting Allowance		$100,000
Engineering and Construction Management [1]		$543,000
	CONSTRUCTION TOTAL	**$2,913,000**
Annual O&M		
Annualized Cost of Inspection (every 5 years)		$10,000
Annualized Cost of Major Repair (every 5 years)		$6,000
Annualized Cost of Minor Screen Repair (every 10 years)		$26,000
Annualized Cost of Replacement (after 30 years)		$39,000
	O&M TOTAL	**$81,000**
Life Cycle		**$4,298,000**

Notes:

[1] Engineering and Construction Management costs estimated as 25 percent of construction subtotal with sales tax.

TABLE 5-4

Summary of Estimated Costs – Alternative 3, In-Lake Cylindrical Screens

Item		Cost
Construction Costs:		
Screen House Improvements Plus Bypass		$2,658,000
In-Lake Cylindrical Screens		
Cylindrical screens		$834,000
Screen manifold		$467,000
Pile-supported structure		$84,000
Electrical/I&C/Site civil		$626,000
	CONSTRUCTION SUBTOTAL	**$4,669,000**
Construction w/ Escalation to February 2016 (6.5%)		$4,973,000
Construction w/ Sales Tax (8.7%)		$5,406,000
Non-Construction Costs:		
Permitting Allowance		$200,000
Engineering and Construction Management [1]		$1,352,000
	CONSTRUCTION TOTAL	**$6,958,000**
Annual O&M		
Drive Energy		$3,000
Annualized Cost of Inspection		$10,000
Annualized Cost of Major Repair (every 5 years)		$7,000
Annualized Cost of Replacement (after 20 years)		$22,000
	O&M TOTAL	**$42,000**
Life Cycle		**$7,675,000**

Notes:

[1] Engineering and Construction Management costs estimated as 25 percent of construction subtotal with sales tax.

TABLE 5-5

Summary of Estimated Costs – Alternative 4, In-Lake Velocity Caps

Item		Cost
Construction Costs:		
Screen House Improvements Plus Bypass		$2,658,000
Velocity Caps		
Velocity caps		$1,001,000
Manifold		$424,000
Pile-supported structure		$167,000
	CONSTRUCTION SUBTOTAL	**$4,250,000**
Construction w/ Escalation to February 2016 (6.5%)		$4,527,000
Construction w/ Sales Tax (8.7%)		$4,921,000
Non-Construction Costs:		
Permitting Allowance		$200,000
Engineering and Construction Management [1]		$1,231,000
	CONSTRUCTION TOTAL	**$6,352,000**
Annual O&M		
Annualized Cost of Inspection (every 5 years)		$3,000
Annualized Cost of Replacement (after 40 years)		$30,000
	O&M TOTAL	**$33,000**
Life Cycle		**$6,913,000**

Notes:

[1] Engineering and Construction Management costs estimated as 25 percent of construction subtotal with sales tax.

TABLE 5-6

Summary of Estimated Costs – Alternative 5, Gate House Site Screening

Item		Cost
Construction Costs:		
Screen House Improvements Plus Bypass		$2,658,000
Gate House Screening		
Bypass caisson		$586,000
Temporary (short-term) lake intake		
Intake w/ cylindrical screen		$251,000
200 feet of 30-inch HDPE pipe		$101,000
On-shore pumping plant and submersible pump		$501,000
Temporary pump discharge piping to Gate House		$76,000
Gate House structure		$4,052,000
Vertical traveling fish screens		$1,701,000
Fish bypass return		$184,000
	CONSTRUCTION SUBTOTAL	**$10,110,000**
Construction w/ Escalation to February 2016 (6.5%)		$10,768,000
Construction w/ Sales Tax (8.7%)		$11,705,000
Non-Construction Costs:		
Permitting Allowance		$300,000
Engineering and Construction Management [1]		$2,927,000
	CONSTRUCTION TOTAL	**$14,932,000**
Annual O&M		
Drive Energy		$20,000
Annualized Cost of Inspection (weekly)		$3,000
Annualized Cost of Major Repair (every 10 years)		$33,000
Annualized Cost of Replacement (after 30 years)		$50,000
	O&M TOTAL	**$106,000**
Life Cycle		**$16,750,000**

Notes:

[1] Engineering and Construction Management costs estimated as 25 percent of construction subtotal with sales tax.

6. Evaluation of Alternative Screening Approaches

The City evaluated the five screening alternatives using a TBL+ process that ensures social, environmental, economic, and technical criteria are effectively and appropriately considered. Four of the five alternatives are presented in the sections above and the fifth alternative is the Screen House Rehabilitation approach that employs the use of the Screen House bypass. This alternative is presented in detail in the July 22, 2014 draft memorandum entitled "City of Bellingham Screen House: Condition Assessment and Improvement Report." In summary, the five screening alternatives evaluated include (alternative numbering revised from that presented in Section 3 above):

- Alternative 1, Screen House Rehabilitation Plus Bypass
- Alternative 2, Screen House Rehabilitation Plus Alternative Supply
- Alternative 3, In-Lake Cylindrical Screens
- Alternative 4, In-Lake Velocity Caps
- Alternative 5, Gate House Site Screening

The evaluation was conducted using a technique called multi-objective decision analysis (MODA). MODA is a quantitative technique that aids evaluation of alternatives where multiple objectives or evaluation criteria warrant consideration. MODA is ideally suited for aiding evaluation processes based on the TBL+ approach. The MODA for this evaluation process included the following key activities:

- Development of evaluation criteria in the TBL+ framework (Environment, Economic, Social, Technical)
- Development of performance measures (measurement scales) for each evaluation criteria
- Scoring of each alternative with respect to each of the evaluation criteria
- Assign weights to the decision criteria to reflect their relative importance to the decision process
- Calculate of the weight-corrected total evaluation scores
- Conduct sensitivity analysis

6.1 Evaluation Criteria

Evaluation criteria presented in Table 6-1 were developed with input from a diverse group of City staff.

TABLE 6-1
Evaluation Criteria

Environment
Shoreline/Wetlands impacts
Fish friendly
Greenhouse gas emissions during construction
Economic
Long-term life cycle costs (40 year)
Social
Aesthetic impacts to public
Technical
Geotechnical risk
Permitting risk
Reliability
Maintenance ease
Regulatory compliance risk
Risk to operations during construction

6.2 Measurement Scales

Measurement scales are required to determine how well alternatives perform against the evaluation criteria. Scales may be quantitative or qualitative, depending on the objective and the availability of data.

The measurement scales developed for this evaluation are presented in Table 6-2.

TABLE 6-2
Measurement Scales

Evaluation Criteria	Best Outcome	Worst Outcome
Environment		
Shoreline/Wetland Impacts	Minimum acres	Maximum acres
Fish friendly	Almost no chance of harm to fish	Substantive numbers of fish die by being trapped in intake system
Greenhouse gas emissions during construction	Minimum truck trips	Maximum truck trips
Economic		
Long-term life cycle costs (40 year)	Minimum dollars	Maximum dollars
Social		
Aesthetic impacts to public	Negligible aesthetic impacts anticipated	Facility likely to result in numerous un-mitigatable aesthetic impacts and complaints
Technical		
Geotechnical risk	Relatively few geotechnical issues that are uncertain with the potential to result in any substantive increase in cost or schedule	Geotechnical issues exist that are uncertain at this time and have the potential to result in a multi-month delay in schedule and/or a cost increase of up to $5 million
Permitting risk	No, or minimal, environmental permitting requirements resulting in no impact to schedule and cost	Excessive environmental permitting requirements resulting in schedule delays and added cost
Reliability	Minimal major maintenance required and no disruption of supply to customers	Continual, major maintenance required and frequent disruption of supply to customers
Maintenance ease	Screening system can be maintained and monitored primarily by City staff with periodic outside technical support	Frequent outside technical support, such as certified divers, is needed to monitor and maintain screens
Regulatory compliance risk	Meets all current and anticipated fish screening requirements	Does not meet fish screening requirements, but is required to meet them in the future
Risk to operations during construction	No disruption of water service to City customers during construction	Extended disruption of water service to City customers during construction

6.3 Scoring Alternatives

Rating or scoring alternatives is the process by which the measurement scales are applied to the alternatives. The alternatives were initially scored by CH2M HILL's technical experts and then reviewed and adjusted by the overall City and consultant project team. A scoring scale of 1 to 5 was implemented for each evaluation criterion except shoreline/wetlands impacts (measured in acres) and long-term life cycle cost (measured in dollars). For the 1-5 scales, the best outcome is given a score of 5 and the worst outcome a score of 1. The scores for each alternative are shown in Table 6-3. The rationale provided for each score is included in Appendix A. These rationale were reviewed and adjusted as necessary by the combined City / consultant project team.

TABLE 6-3
Evaluation Scores for Screening Alternatives

Evaluation Criteria	Alternative 1, Screen House Rehabilitation Plus Bypass	Alternative 2, Screen House Rehabilitation Plus Alternative Supply	Alternative 3, In-Lake Cylindrical Screens	Alternative 4, In-Lake Velocity Cap	Alternative 5, Gate House Site Screening
Environmental					
Shoreline/Wetlands impacts	0.0	0.0	0.0	0.0	1.0
Fish friendly	2	2	5	4	4
Greenhouse gas during construction	3	4	2	2	1
Economic					
Long-term life cycle costs (40 year)	$5,333,000	$4,298,000	$7,675,000	$6,913,000	$16,750,000
Social					
Aesthetic impacts to public	4	4	4	4	1
Technical					
Geotechnical risk	2	4	1	1	1
Permitting risk	4	3.5	2	2	1
Reliability	4	5	2	4	4
Maintenance ease	3	3	1	2	4
Regulatory compliance risk	3	3	5	4	5
Risk to operations during construction	2	4	2	2	2

6.4 Relative Value Weights

Evaluation criteria vary in their importance to making a decision about the relative merits of alternatives. Thus, relative value weights are assigned to each criterion that represent the importance of each criterion for decision making. For this evaluation, weights were assigned by each member of the City's project team, and discussed in a workshop. The consensus set of weights for the evaluation criteria are presented in Table 6-4.

TABLE 6-4
Project Team Consensus Weights

Evaluation Criteria	Weights
Environmental	**21%**
Shoreline/Wetlands impacts	8%
Fish friendly	9%
Greenhouse gas emissions during construction	4%
Economic	**11%**
Long-term life cycle costs (40 year)	11%
Social	**6%**
Aesthetic impacts to public	6%
Technical	**62%**
Geotechnical risk	8%
Permitting risk	8%
Reliability	12%
Maintenance ease	12%
Regulatory compliance risk	11%
Risk to operations during construction	12%

Note: Totals may not add due to rounding

6.5 Results

The total value score for each alternative was calculated as a weighted averaging process. In MODA, the raw scores shown in Table 6-3 are arithmetically transformed to a scale of zero-to-one (to allow comparison between criteria with different measurement scales like dollars and 1-5). The normalized scores were multiplied by the weights presented in Table 6-4 and summed for each alternative. The results were multiplied by 100 so that MODA scores range between 0 and 100 rather than as decimals. Resulting MODA scores for the consensus weights are presented in Table 6-5 and Exhibit 6-1.

TABLE 6-5
MODA Results for Screening Alternatives

	Alternative 1 Screen House Rehabilitation Plus Bypass	Alternative 2 Screen House Rehabilitation Plus Alternative Supply	Alternative 3 In-Lake Cylindrical Screens	Alternative 4 In-Lake Velocity Cap	Alternative 5 Gate House Site Screening
Environmental	12.5	13.5	18.3	16.1	6.8
Economic	9.8	10.6	7.8	8.4	0.0
Social	4.8	4.8	4.8	4.8	0.0
Technical	30.8	42.7	18.8	24.9	31.5
Total	**57.8**	**71.6**	**49.6**	**54.1**	**38.4**

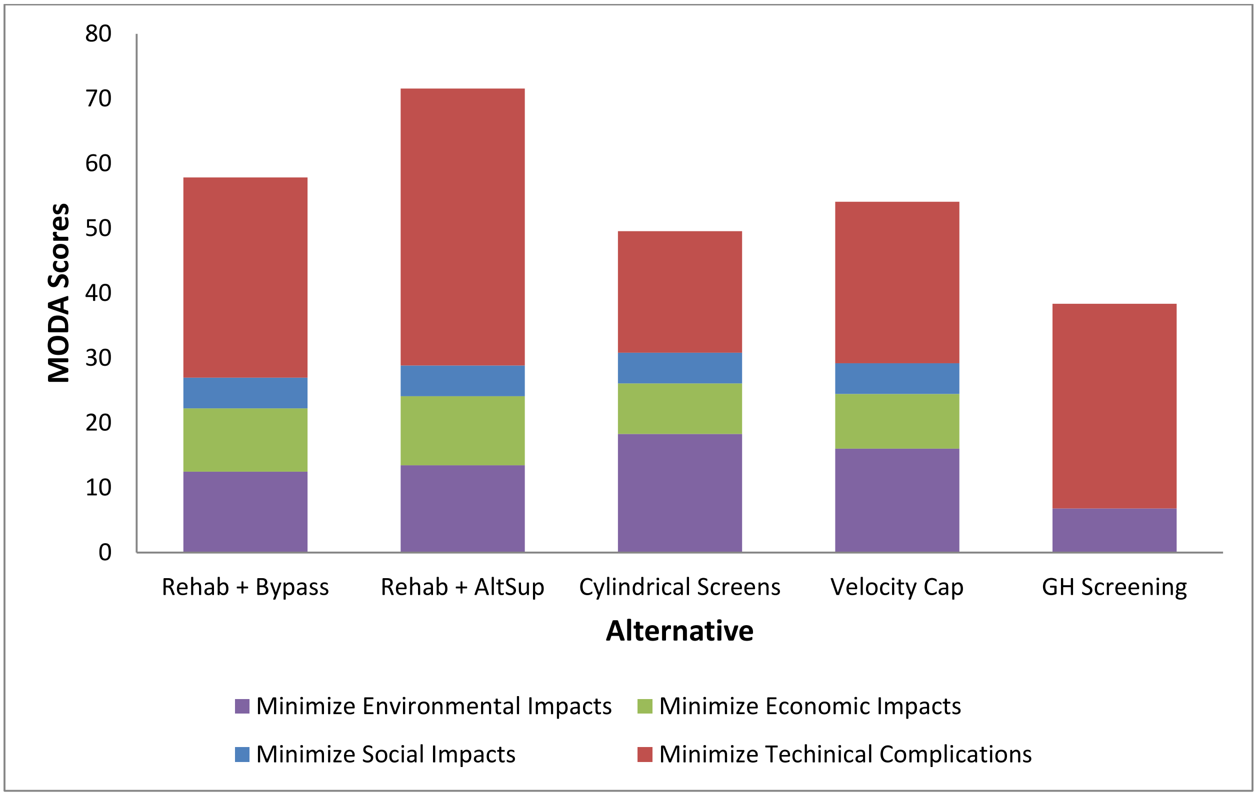


Exhibit 6-1. MODA Results

As shown, rehabilitation of the existing Screen House plus development of the alternative supply scores far higher than the other alternatives – reflecting its many advantages over the other alternatives. The main reason for this is that Alternative 1 is higher cost and higher risk. The higher risk is associated with the tunnel connection. Alternatives 3, 4, and 5 each must incorporate essentially all of Alternative 2 to enable continued use of the existing Screen House to connect the tunnel to the downstream municipal and industrial supply pipelines. As a result, each of these alternatives have substantially higher cost with only minimal additional benefit.

A graphical presentation of the sensitivity of the results is included as Exhibit 6-2. This figure shows the sensitivity of the results to the different weightings of the evaluation criteria of each of the six City staff that participated in the evaluation process. As shown, rehabilitation of the Screen House plus development of the alternative supply is strongly preferred by each of the participants to all other alternatives, regardless of differing weights assigned to each evaluation criteria.

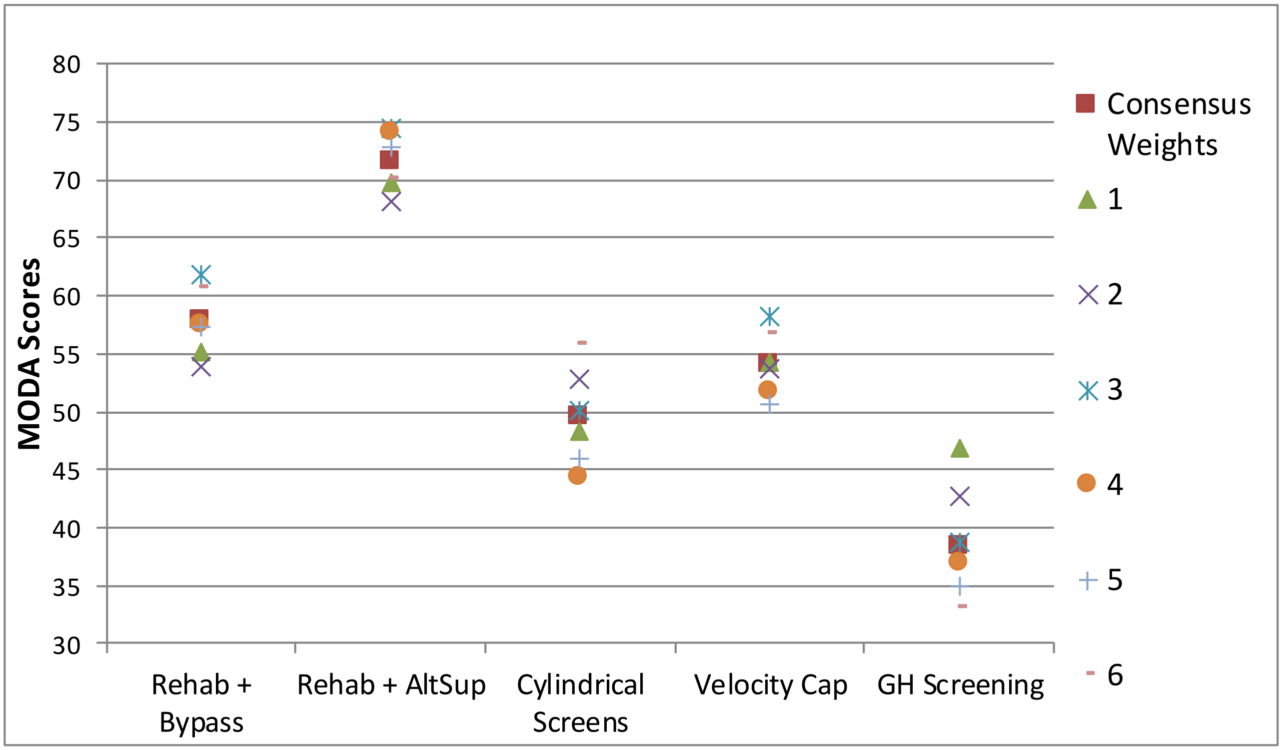


Exhibit 6-2. Sensitivity of MODA Scores to Changes in Weights

6.6 Conclusions

Development of the City's "old" supply system as a temporary backup supply that enables bypassing of the existing Screen House is clearly the superior alternative for continuing beneficial use of the Screen House and its critical screening function. This alternative affords another advantage that none of the other alternatives do; it can serve as an emergency backup supply that enables bypassing of the existing 72-inch diameter wood-stave intake pipeline, the existing Gate House, the existing tunnel, and the existing Screen House. This long-term advantage will enable the City to more effectively and pro-actively maintain and rehabilitate these existing facilities.

Figures

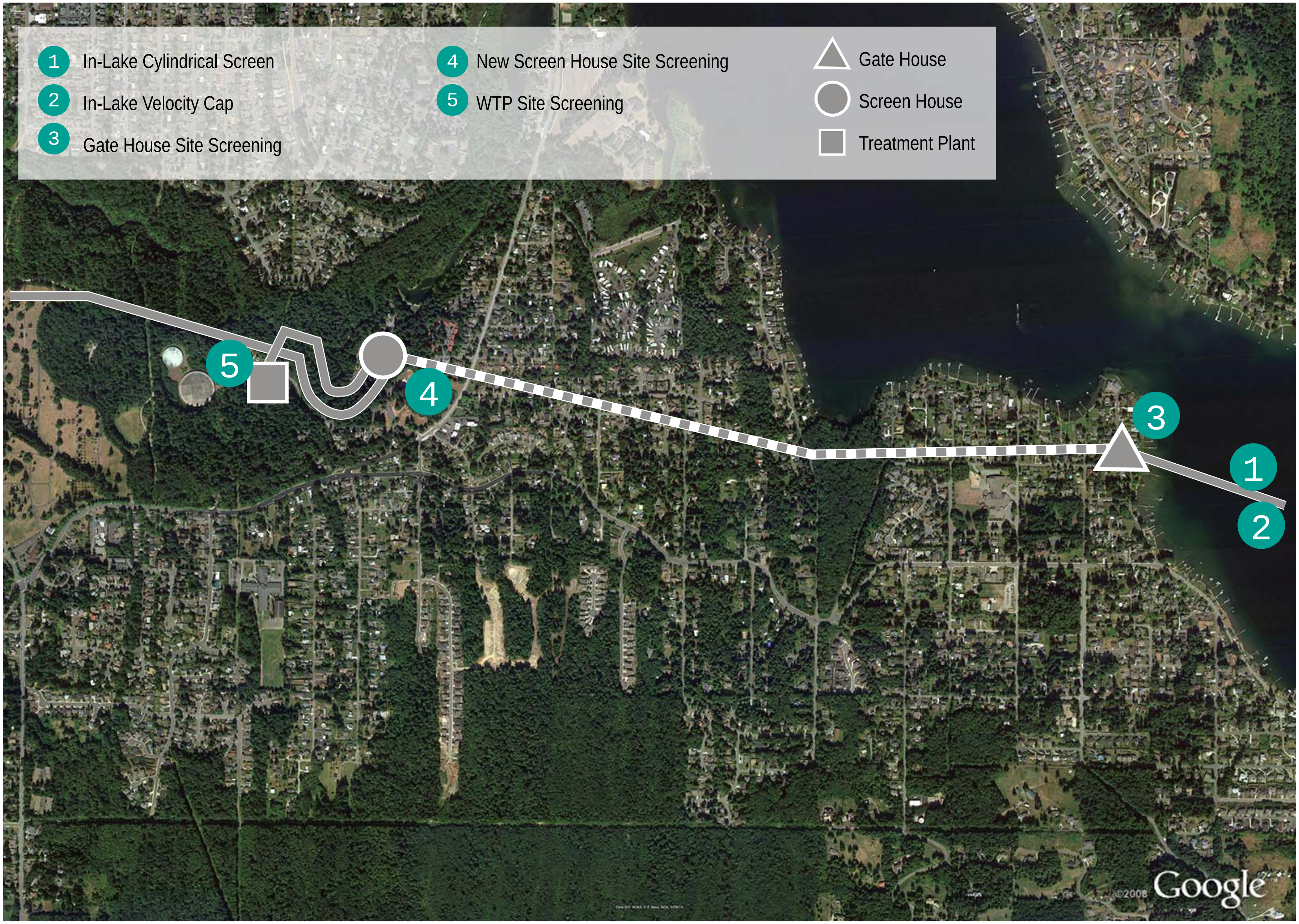


Figure 1
Overview of Alternatives
Whatcom Falls WTP Pretreatment Project

Figure 2
Alternative 1 In-Lake Cylindrical Screen Photo
Whatcom Falls WTP Pretreatment Project

CH2MHILL®

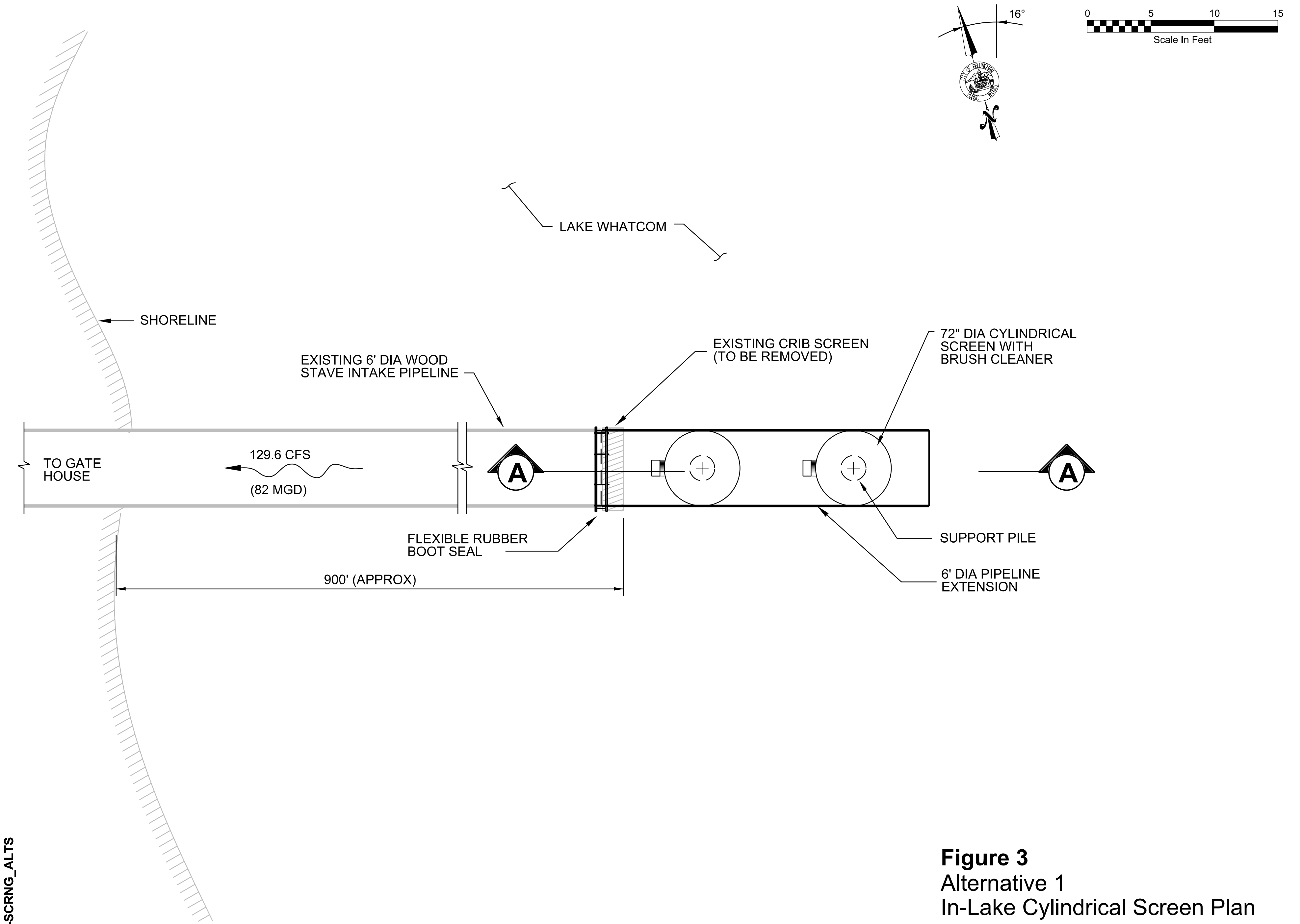
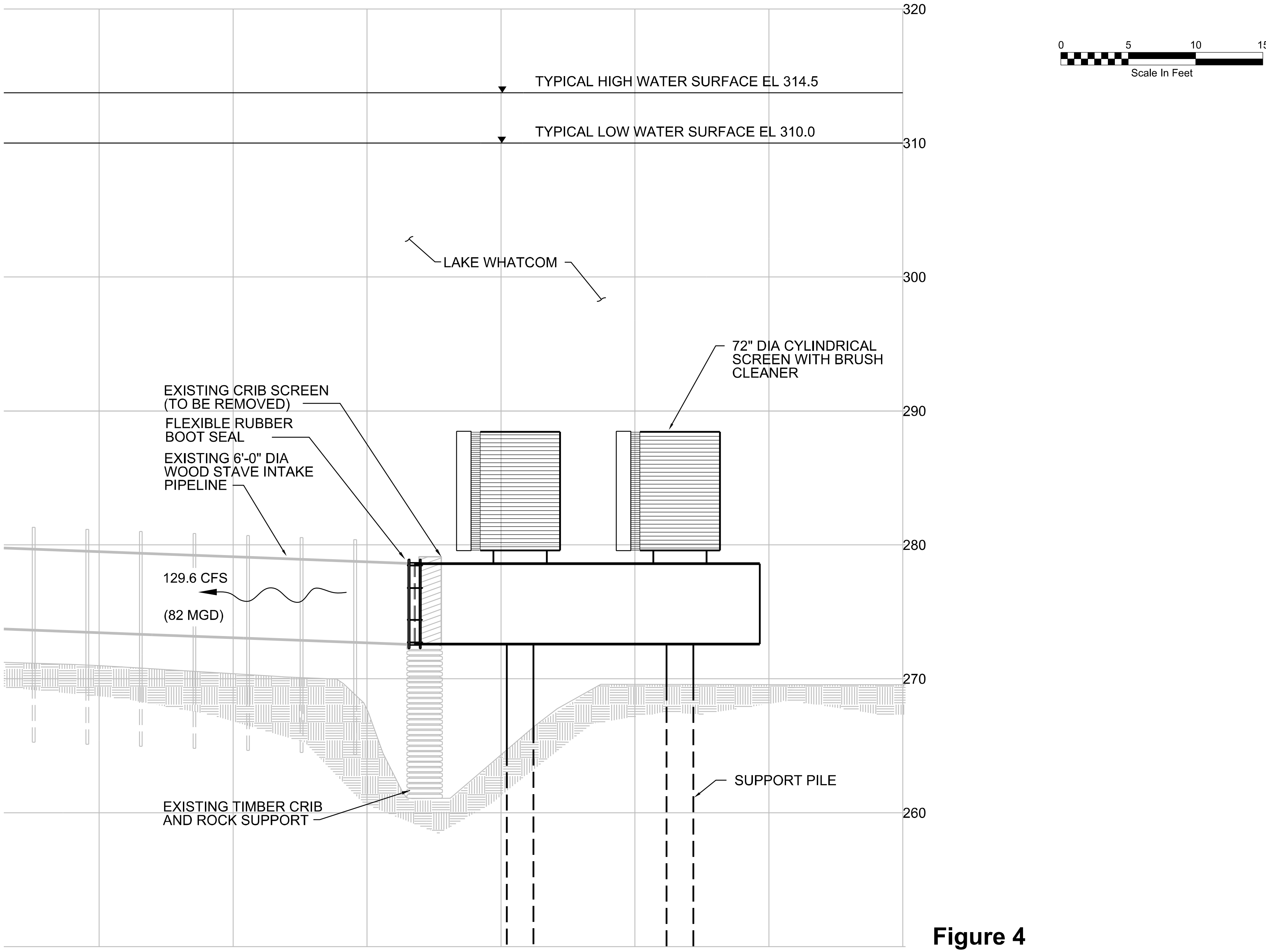


Figure 3
Alternative 1
In-Lake Cylindrical Screen Plan

CH2MHILL



488508-SCRNG_ALTS

Figure 4
Alternative 1
In-Lake Cylindrical Screen Section

CH2MHILL®

Figure 5
Velocity Cap
Whatcom Falls WTP Pretreatment Project

CH2MHILL®

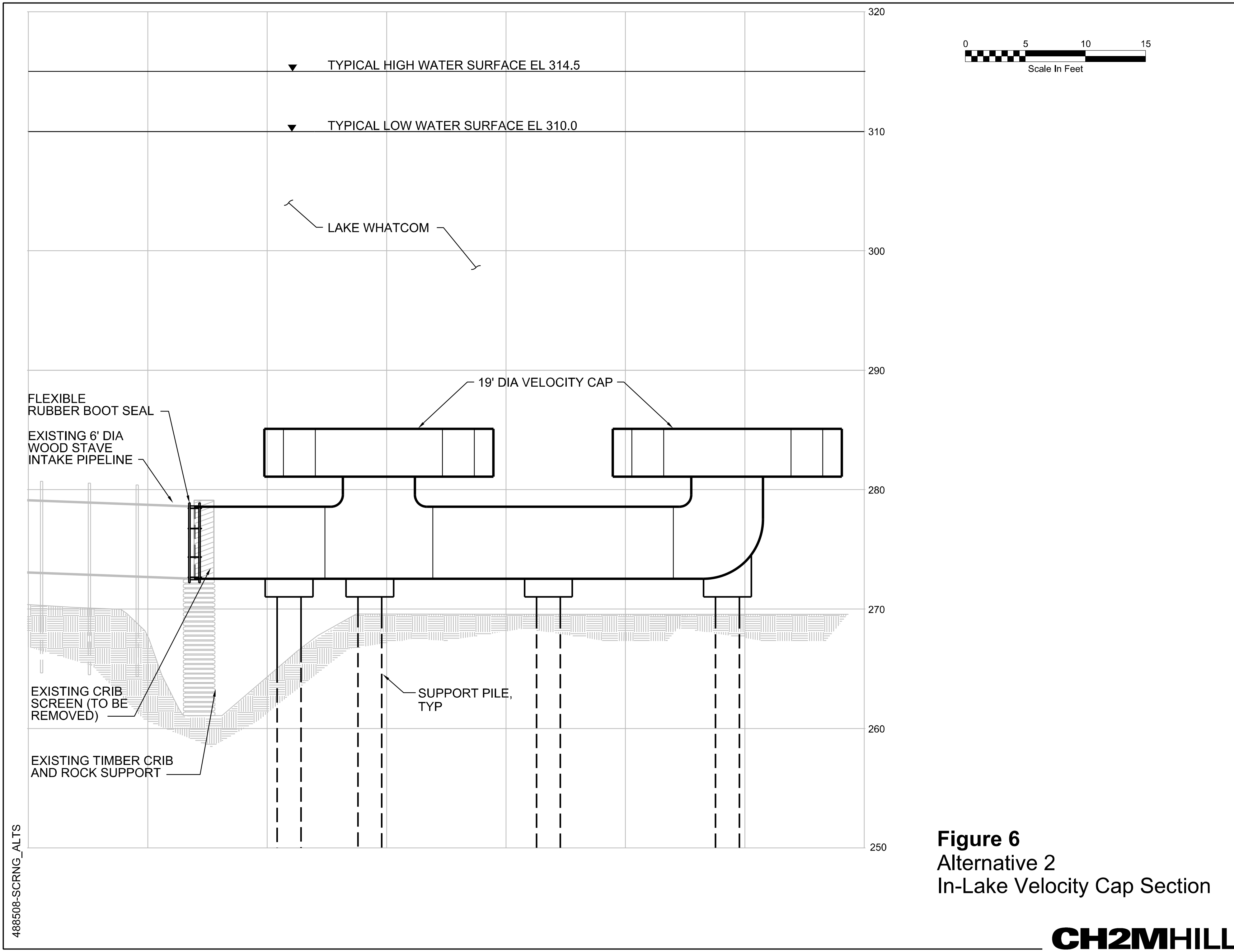


Figure 6
Alternative 2
In-Lake Velocity Cap Section

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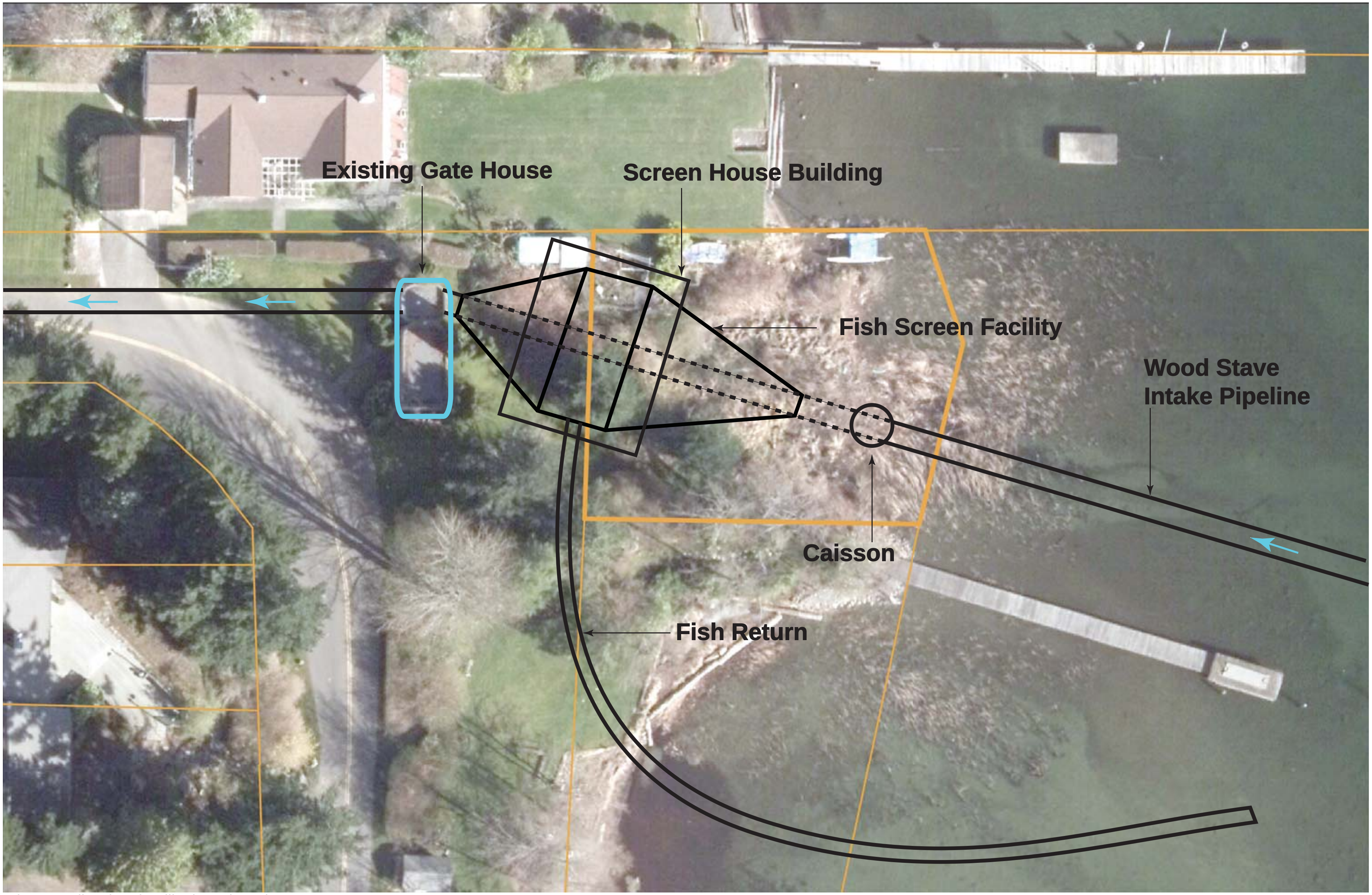

Photo credit: City of Bellingham (2013)

LEGEND

- Parcel Line
- City Property
- Gate House Building Outline

North

0 40
Approximate scale in feet

Figure 7
Alternative 3 Gate House Site Screening Aerial Layout
Whatcom Falls WTP Pretreatment Project

WBG080414233907BOI

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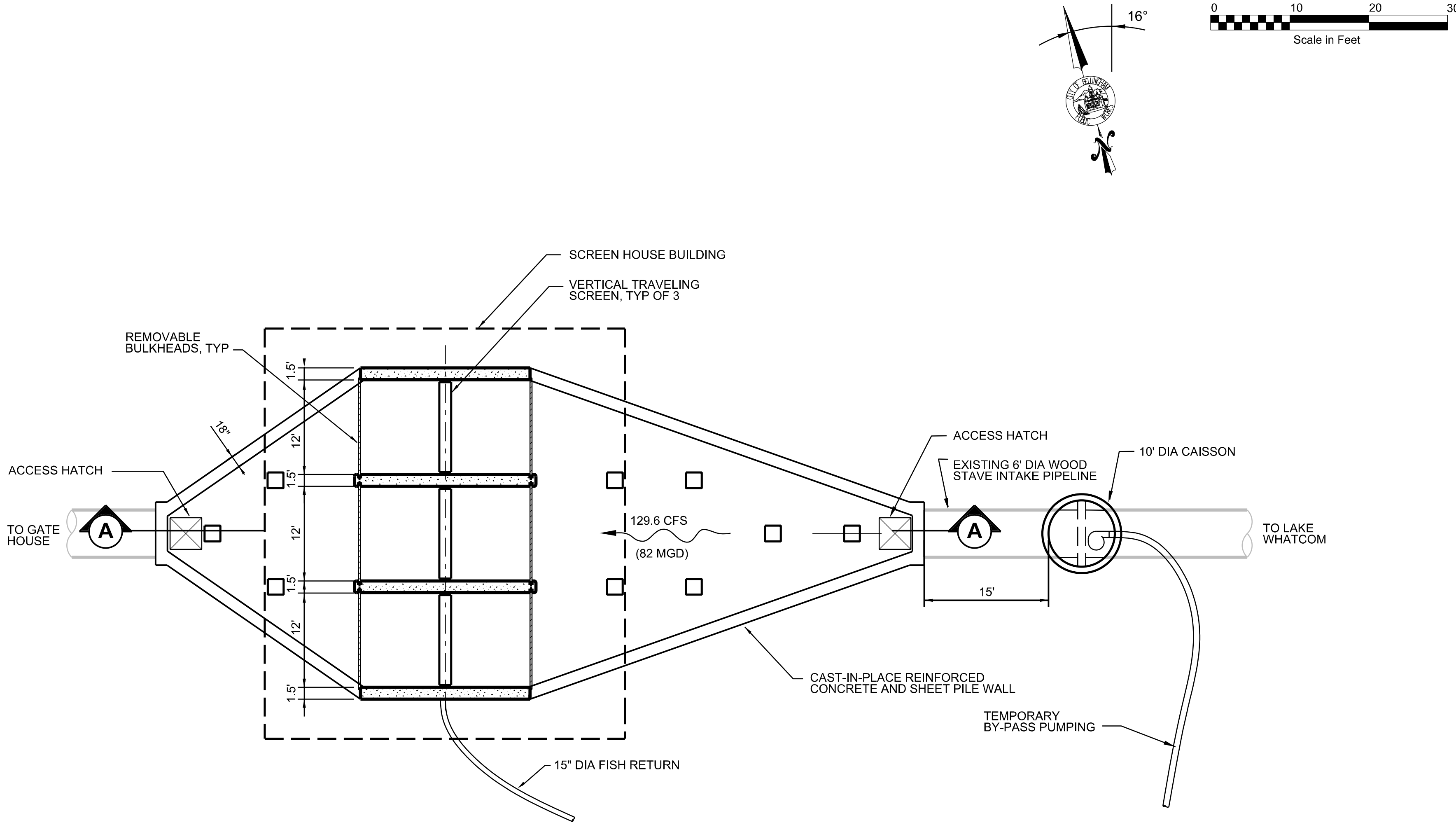

488508-SCRNG_ALTS

Figure 8
Alternative 3
Gate House Site Screening Plan

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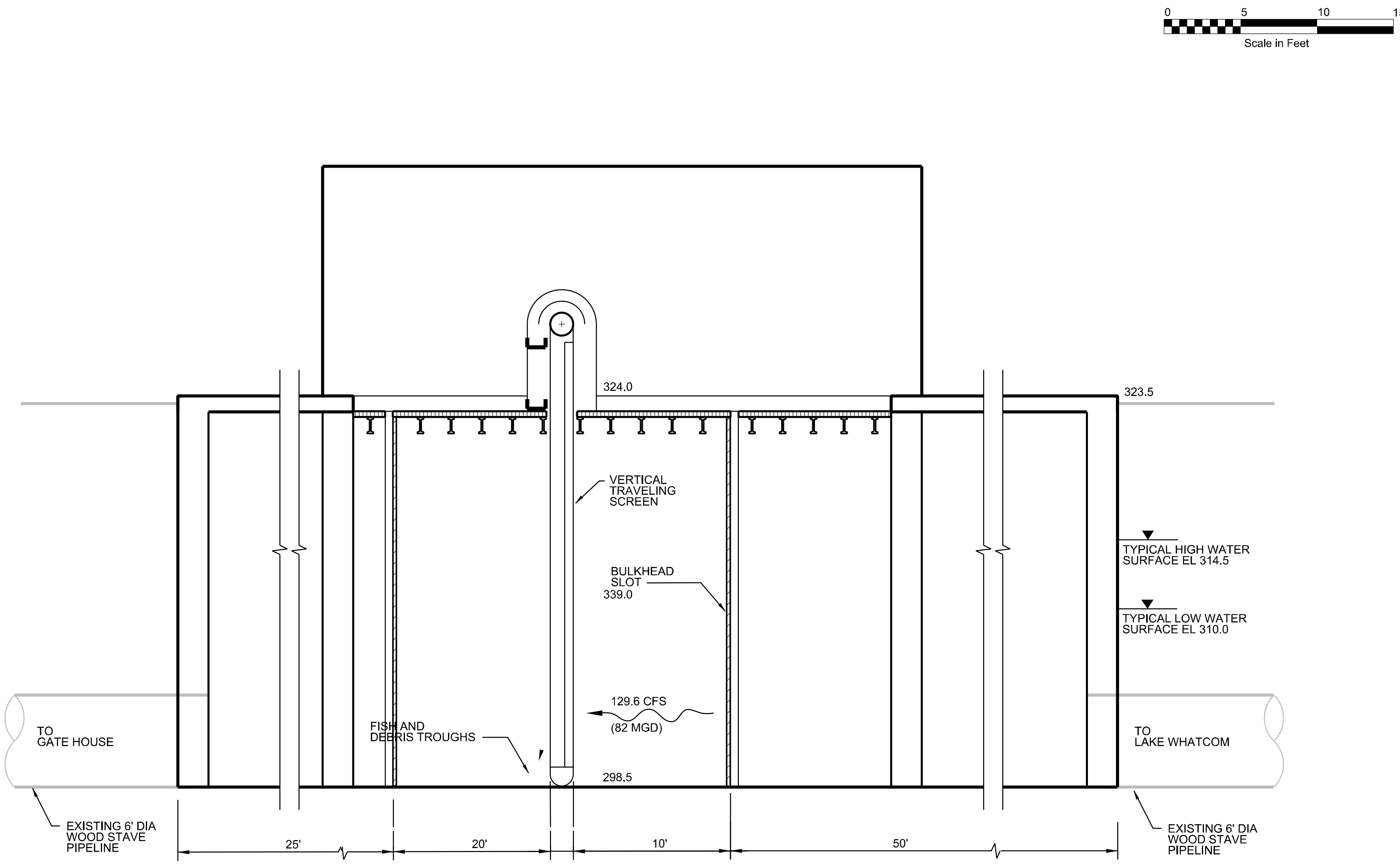

Figure 9
Alternative 3
Gate House Site Screening Section

CH2MHILL.

Aerial image © 2014 Google Earth. © 2014 Data SIO, NOAA, U.S. Navy, NGA, GEBCO. Annotation © 2014 CH2M HILL.

Figure 10
Old City of Bellingham Water Supply
Whatcom Falls WTP Pretreatment Project

WBG080414233907BOI

CH2MHILL.

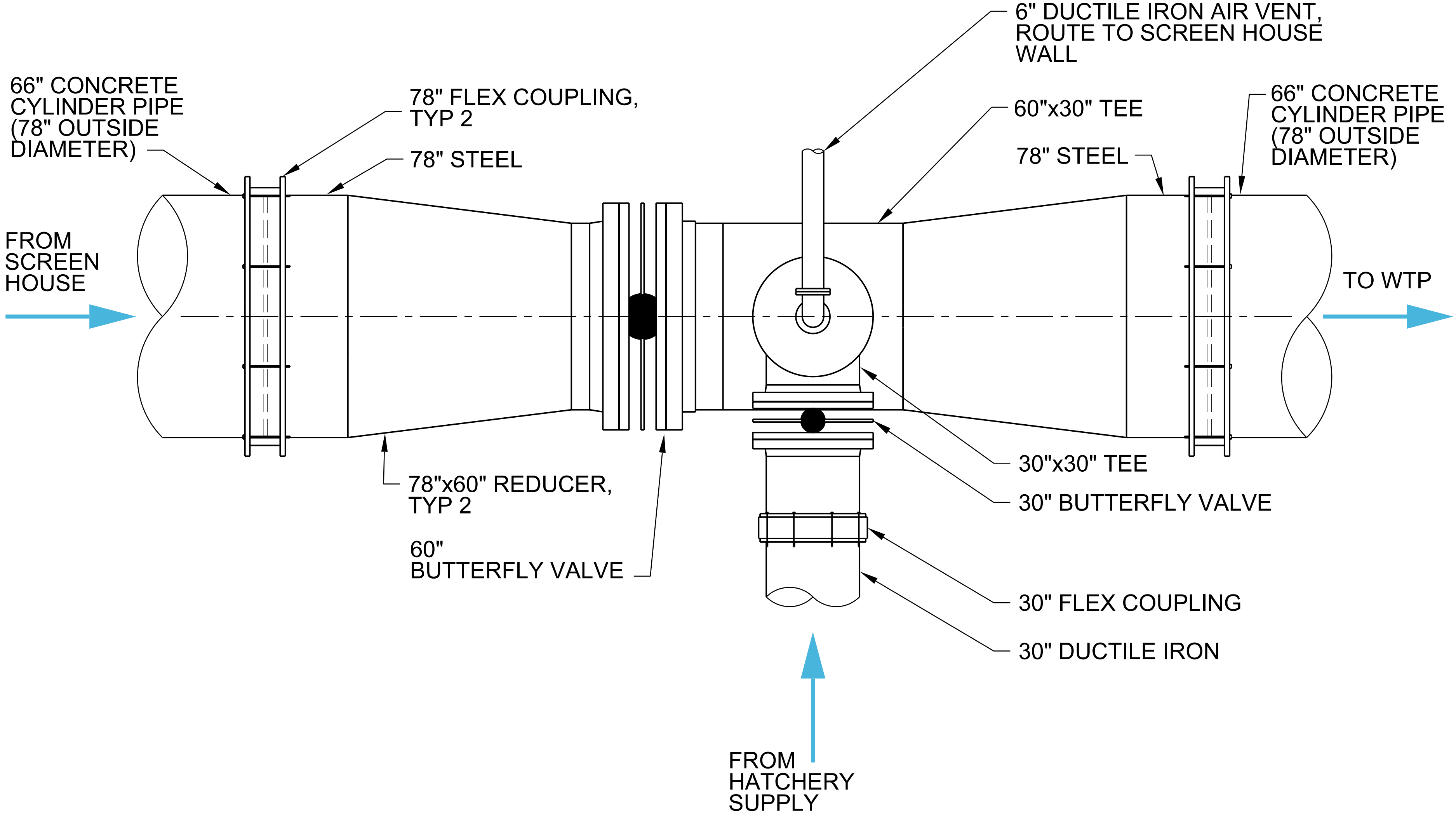

Figure 11
Connection to
Hatchery Supply Plan

0 2 4 6
SCALE IN FEET

CH2MHILL

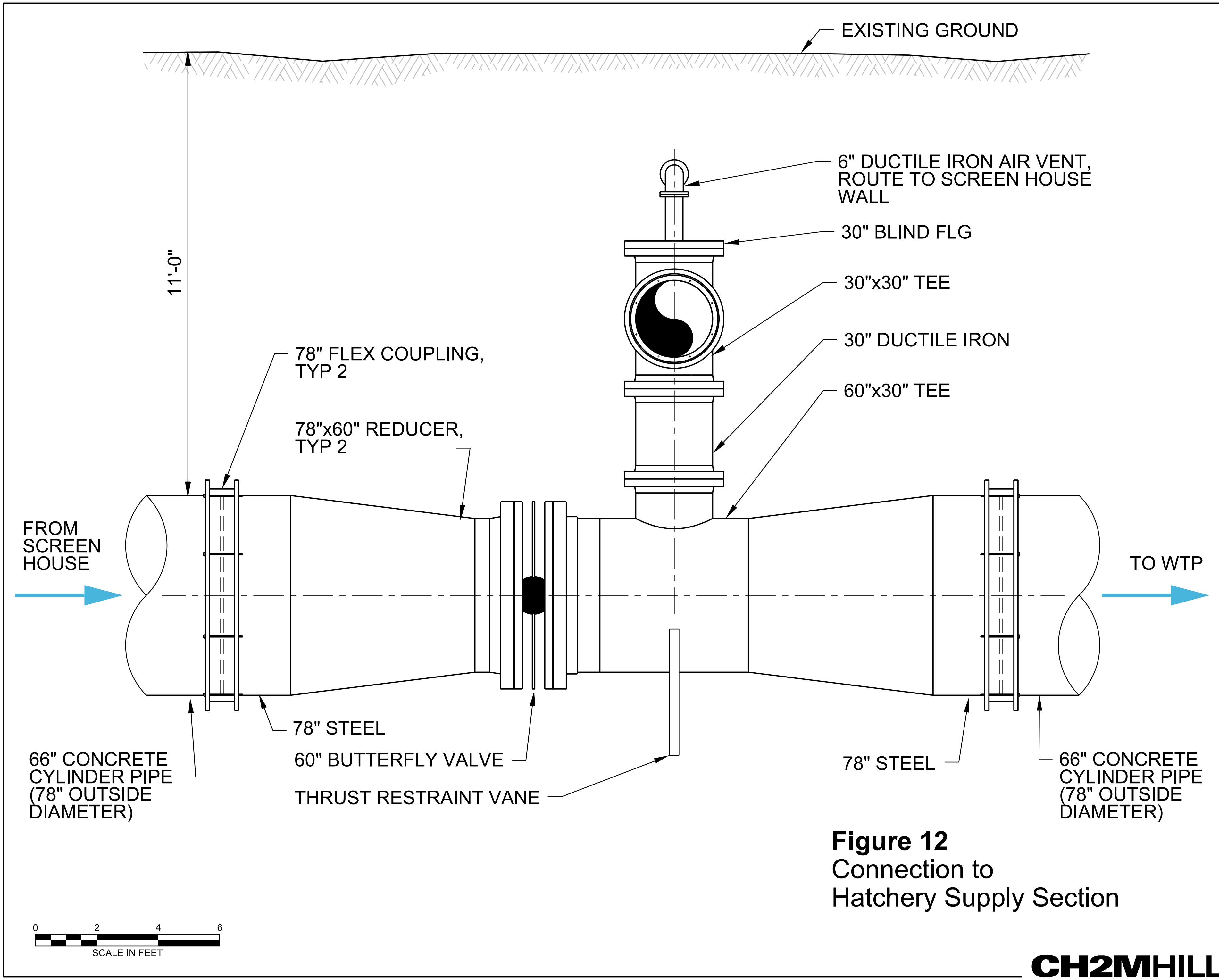

Figure 12
Connection to
Hatchery Supply Section

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Appendix A – TBL+ Scoring Rationale for Screening Alternatives

City of Bellingham Screen House

Triple Bottom Line + Scoring Rationale for Screening Alternatives

Evaluation Criteria	Performance Measure	Rationale 1 Rehab + Bypass	Rationale 2 Rehab + AltSup	Rationale 3 Cylindrical Screens	Rationale 4 Velocity Cap	Rationale 5 GH Screening
Environment						
Shoreline/Wetlands impacts	Acres					
Fish friendly	1-5, 5 is best	Very low fish survival rate.	Very low fish survival rate.	Fish remain in lake.	Fish mostly remain in lake.	Fish returned to lake.
Greenhouse gas emissions during construction	1-5, 5 is best	Extensive excavation associated with bypass.	Moderate excavation.	Extensive excavation associated with bypass.	Extensive excavation associated with bypass.	Extensive excavation associated with bypass; plus extensive shoreline excavation and construction.
Economic						
Long-term life cycle costs (40 year)	Dollars					
Capital cost	Dollars					
Social						
Aesthetic impacts to public	1-5, 5 is best	Impact during construction only.	Impact during construction only.	Impact during construction only.	Impact during construction only.	Highly visible shoreline facility.
Technical						
Geotechnical risk	1-5, 5 is best	Tunnel must be encased within rock for successful connection to bypass.	Relatively shallow pipeline installation required.	Tunnel must be encased within rock for successful connection to bypass; plus additional risk with pile driving.	Tunnel must be encased within rock for successful connection to bypass; plus additional risk with pile driving.	Tunnel must be encased within rock for successful connection to bypass; plus additional risk with deep excavation on shoreline.
Permitting risk	1-5, 5 is best	Minimal environmental permitting required.	Minimal environmental permitting required.	Environmental permitting required for in-lake work.	Environmental permitting required for in-lake work.	Extensive environmental permitting required for in-lake and on-shore work.
Reliability	1-5, 5 is best	Maintenance required but system accessible.	Maintenance required but system accessible.	Maintenance required and challenging accessibility.	Minimal maintenance required but accessibility challenging.	Maintenance required but system accessible.
Maintenance ease	1-5, 5 is best	Existing traveling screens are old but readily accessible.	Existing traveling screens are old but readily accessible.	Mechanical system not accessible to City staff.	Static system not accessible to City staff.	New screening system readily accessible.
Regulatory compliance risk	1-5, 5 is best	"Grandfather" status.	"Grandfather" status.	Fish remain in lake.	Most fish remain in lake.	Fish returned to lake.
Risk to operations during construction	1-5, 5 is best	Bypass connection to tunnel is risky.	No connection to tunnel necessary.	Bypass connection to tunnel is risky.	Bypass connection to tunnel is risky.	Bypass connection to tunnel is risky.