Draft Alternatives Review – Downstream Fish Passage at the Brunswick Project

ID	Alternative	Description	Effectiveness	Safety	Equipment Longevity	Risk/Uncertainty	Constructability	Construction Costs	Operation and Maintenance Costs	Impacts to Generation
D1	**Angled Bar Rack with New Downstream Bypass Structures**	-This alternative would include the installation of a new, full-depth angled bar rack with close-spaced trash racks (3/4-inch clear) upstream of the existing intake structures. -The angled bar rack would extend approximately 140 feet upstream of the existing intake structure and would be angled at 45 degrees. An isolation wall between Unit 1 and 2 would be provided to allow for a deeper intake in front of Unit 1. The intake for Unit 1 would be approximately 80 feet wide by 35 feet deep resulting in an average approach velocity of approximately 1.8 fps. The intake for Units 2 and 3 would be approximately 68 feet wide by 20 feet deep resulting in an average approach velocity of approximately 1.8 fps. -A new surface bypasses would be provided at the downstream end of the racks located on the south side of the spillway adjacent to the powerhouse. -A new low-level bypass would be provided at the downstream end of the racks for the downstream eel passage. The bypass would be routed to a surface weir located adjacent to the surface bypass. -Total bypass flow would be approximately 375 cfs (5% of station discharge). Fish would be discharged directly into the tailrace downstream of the spillway if it is shown to be deep enough, otherwise a plunge pool that meets USFWS criteria would be provided. -A new mechanical trash rake would be installed for debris management.	<u>High</u> -Reduced passage mortality through the turbine intakes. -Improves protection of fish exiting upstream fish ladder.	<u>Moderate Risk</u> -More frequent debris raking operations required. -Periodic dive inspections needed for cleaning low level bypass.	<u>High</u> -All new intake structure, downstream bypass structures, and a new trash rake.	<u>Low</u> -The location of the bypass structures may impact the spillway discharge capacity. Modifications to the spillway may be required to maintain the discharge capacity and prevent impacting the 100-year flood elevation or the IDF elevation. -The new intake structure may impact the exit of the upstream passage facility. Some modification may be required to accommodate new intake wall. -Possible hot spots at the downstream end of the rack. CFD modeling is needed to confirm the feasibility of this alternative.	<u>Difficult</u> -A large cofferdam will likely be required to facilitate construction. -If required modifications to the spillway would be challenging requiring work from a barge and installation of flood protection upstream of the work area. -A cofferdam would likely be required to facilitate construction of a plunge pool if required.	<u>High</u> -Construction costs of the new intake structure. -Construction costs of the new low-level and surface bypass structures. -New trash rake costs. -Electrical supply for the new bypass gates and trash rake. -Possible spillway modification costs. -Possible plunge pool construction costs.	<u>Moderate-High</u> -More frequent raking and debris handling required. -Increased potential for frazil ice impacts. -Effectiveness testing required.	<u>Moderate</u> -Additional losses due to increased attraction flow. -Slightly higher energy loss due to close-spaced racks and increased debris loading. -Increased potential for frazil ice impacts.
D2	**Inclined Bar Rack with New Downstream Bypass Structures**	-This alternative would include the installation of a new, full-depth inclined bar rack with close-spaced trash racks (3/4-inch clear) upstream of the existing intake structures. -Separate inclined rack structures would be provided for Unit 1 and Units 2 and 3 due to the increased water depth in front of Unit 1. Both intake structures would have a rack inclination of 45 degrees. The intake for Unit 1 would be approximately 55 feet wide and would extend approximately 55 feet upstream of the existing intake structure resulting in an average approach velocity of approximately 1.7 fps. The intake for Units 2 & 3 would be approximately 48 feet wide and would extend	<u>High</u> -Reduced passage mortality through the turbine intakes. Improves protection of fish exiting upstream fish ladder.	<u>Moderate Risk</u> -More frequent debris raking operations required. -Periodic dive inspections needed for cleaning low level bypass.	<u>High</u> -All new intake structure, downstream bypass structures, and a new trash rake.	<u>Moderate</u> -The location of the bypass structures may impact the spillway discharge capacity. Modifications to the spillway may be required to maintain the discharge capacity and prevent impacting the 100-year flood elevation or the IDF elevation. -The new intake structure may impact	<u>Difficult</u> -A large cofferdam will be required to facilitate construction. -A custom trash rake may be required to accommodate the inclined rack angle and additional reach. -If required modifications to the spillway would be challenging requiring work from a barge	<u>High</u> -Construction costs of new intake structure. -Construction costs of new low-level and surface bypass structures. -New trash rake costs. -Electrical supply for new bypass gates and trash rake.	<u>Moderate-High</u> -More frequent raking and debris handling required. -Increased potential for frazil ice impacts. -Effectiveness testing required.	<u>Moderate</u> -Additional losses due to increased attraction flow. -Slightly higher energy loss due to close-spaced racks and increased debris loading. -Increased potential for frazil ice impacts.

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		approximately 35 feet upstream of the existing intake structure resulting in an average approach velocity of approximately 1.8 fps. -A new surface bypasses would be provided on the south side of the spillway adjacent to the powerhouse. -A new low-level bypass would be provided for downstream eel passage. The bypass would be routed to a surface weir located adjacent to the surface bypass. -Total bypass flow would be approximately 375 cfs (5% of station discharge). Fish would be discharged directly into the tailrace downstream of the spillway if it is shown to be deep enough, otherwise a plunge pool that meets USFWS criteria would be provided. -A new mechanical trash rake would be installed for debris management.				the exit of the upstream passage facility. Some modification may be required to accommodate new intake wall -This technology has not been widely used in the U.S. and is still considered experimental. -Possible hot spots on the proposed rack structure. CFD modeling is needed to confirm the feasibility of this alternative.	and installation of flood protection upstream of the work area. -A cofferdam would likely be required to facilitate construction of a plunge pool if required.	-Possible spillway modification costs. -Possible plunge pool construction costs.		
D3	**Floating Guidance Boom with a New Downstream Surface Bypass and Nighttime Shutdowns**	-This alternative would include the installation of a new 10-foot-deep floating fish guidance boom (e.g., PNP or Worthington). -The boom would extend from the north side of the powerhouse to the shoreline at approximately a 35-degree angle. -A new surface bypass would be provided at the downstream end of the guidance boom located on the south side of the spillway adjacent to the powerhouse. -Due to the boom only being partial depth, a low-level bypass would not be provided. -Total bypass flow would be approximately 375 cfs (5% of station discharge). Fish would be discharged directly into the tailrace downstream of the spillway if it is shown to be deep enough, otherwise a plunge pool that meets USFWS criteria would be provided.	<u>Low</u> -There is the potential for downstream migrants to sound below the guidance boom which would result in reduced efficiency when compared to other full depth exclusion measures. -Modeling of a similar alternative by Blue Hill Hydraulics Inc. showed poor guidance at the downstream end of the boom. -Nighttime shutdowns required for protection of out-migrating American eels.	<u>High Risk</u> -Due to safety concerns with trying to install the boom annually during high flow conditions the boom would be designed to be installed year-round. Shear pins that are designed to fail under extreme loads would be provided to prevent excessive damage to the boom. This will require boat access to reset the boom periodically. -Debris accumulation in the catenary of the guidance boom may occur which would require periodic boat access to remove. -Periodic dive inspections will be needed to clean biofouling from the guidance boom.	<u>Low</u> -The existing intake racks would remain in place. -The floating guidance boom is more susceptible to damage from high flow, debris, and ice.	<u>Moderate</u> -The location of the bypass structure may impact the spillway discharge capacity. Modifications to the spillway may be required to maintain the discharge capacity and prevent impacting the 100-year flood elevation or the IDF elevation. -This alternative may impact upstream migrants that would need to sound below the guidance boom. An extension to the upstream fishway exit may be required.	<u>Moderate</u> -Installation of the boom will require a crane and personnel on the water to position the boom sections. -In-water anchors may be required to resist debris and ice loading. -If required modifications to the spillway would be challenging requiring work from a barge and installation of flood protection. -New anchor block construction may temporarily impact mill building parking.	<u>Low</u> -Cost of boom supply and installation. -Cost of boom anchorages -Construction costs of new surface bypass structure. -Electrical supply for new bypass gate. -Possible spillway modification costs. -Possible plunge pool construction costs.	<u>High</u> -Divers required for periodic cleaning of the guidance boom. -Boom may need to be reset after extreme flow events. -Periodic debris removal. -Effectiveness testing required.	<u>High</u> -Additional losses due to increased attraction flow. shutdowns. -Additional losses due to nighttime shutdowns.

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D4A	**Multiple Fish Friendly Runner Replacements**	-This alternative would include replacing the existing turbine runners of all three units with Natel FishSafe runners. -The Existing 3-1/2 inch clear intake racks to remain. -No other downstream passage or protection measures would be provided. -The existing debris management systems for the powerhouse trash racks would continue to be used.	Experimental -Turbine survival rates depend on species, type of turbine, and site-specific hydraulic conditions. -A feasibility study by Natel will be required to fully assess this alternative.	Low Risk -No changes to existing operating procedures.	Moderate -New runners will extend the service life of existing units.	Experimental -This technology is gaining preliminary agency acceptance; however, it is still considered experimental due to the lack of large-scale effectiveness testing.	Easy -Assuming runner replacement is feasible and that full turbine replacement is not required.	Moderate -Supply and installation cost of new runners.	Low -Maintenance of new units would be similar to existing units. -Eliminates O&M associated with downstream bypass structures. -Effectiveness testing required.	Unknown -Impacts to generation are likely to be low but a feasibility study by Natel will be required to fully assess this.
D4B	**Unit 1 Fish Friendly Runner Replacement with Inclined Bar Rack at Units 2 and 3**	-This alternative would include replacing the existing turbine runner for Unit 1 with a Natel FishSafe runner and installing an inclined bar rack with close-spaced trash racks (3/4-inch clear) upstream of the existing intake structure for Units 2 & 3. Note flows exceed discharge capacity of Unit 1 48% of the downstream passage season. -The Existing 3-1/2 inch clear intake racks at Unit 1 would remain. -The intake for Units 2 & 3 would be approximately 48 feet wide and would extend approximately 35 feet upstream of the existing intake structure resulting in an average approach velocity of approximately 1.8 fps. -No other downstream passage or protection measures would be provided. -A new mechanical rake would be installed for debris management.	Experimental -Turbine survival rates depend on species, type of turbine, and site-specific hydraulic conditions. -A feasibility study by Natel will be required to fully assess this alternative.	Moderate Risk -More frequent debris raking operations will be required for Units 2 & 3.	Moderate-High -New runners will extend the service life of existing units. -New intake structure and new trash rake for Units 2 & 3.	Experimental -FishSafe runner technology is gaining preliminary agency acceptance; however, it is still considered experimental due to the lack of large-scale effectiveness testing. -Inclined trash racks have not been widely used in the U.S. and is still considered experimental. -Possible hot spots on the proposed rack structure. CFD modeling is needed to confirm the feasibility of this alternative.	Difficult -A large cofferdam will be required to facilitate construction of the new intake structure. -Custom trash rake may be required to accommodate incline angle.	Moderate-High -Construction costs of new intake structure. -Supply and installation cost of new runner. -New trash rake costs. -Electrical supply for new trash rake.	Moderate -More frequent raking and debris handling required at Units 2&3 -Increased potential for frazzle ice impacts on Units 2 and 3 racks. -Effectiveness testing required.	Unknown -Impacts to generation are likely to be low but a feasibility study by Natel will be required to fully assess this. -Slightly higher energy loss due to close-spaced racks and increased debris loading on Units 2 & 3.
ALTERNATIVES RULED OUT										
-	**No Action (Maintain Existing Conditions)**	This was eliminated due to the approach velocities (Unit 1 – 3.2 fps, Unit 2&3 2.8 fps) and bar spacing (3-1/2 inch clear spacing) of the existing trash racks which exceeds maximums recommended by USFWS. The attraction flow (20cfs) for the downstream bypass is also significantly lower than the 5% of station discharge (375 cfs) that is recommended by USFWS.	-	-	-	-	-	-	-	-
-	**Modifications to the Existing Downstream Bypass**	The existing downstream bypass consists of a 3.5-foot-wide surface sluice that transitions to an 18-inch diameter pipe that is routed through	-	-	-	-	-	-	-	-

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		the powerhouse. The bypass discharges 20 cfs. This was eliminated because it is not likely feasible to modify the existing bypass to pass the increased attraction flow that will be required.								
-	**Shutdown One Unit and use it as a Bypass Route**	This was eliminated due to the lost generation and the need to provide fish exclusion measures for the other two units.	–	–	–	–	–	–	–	–
-	**Replace Existing Racks with Close-Spaced Racks and Install New Downstream Bypass Structures**	This was eliminated since the approach velocities (Unit 1 – 3.2 fps, Unit 2&3 2.8 fps) exceed maximums recommended by USFWS.	–	–	–	–	–	–	–	–
	Seasonal Overlays	This was eliminated since the approach velocities (Unit 1 – 3.2 fps, Unit 2&3 2.8 fps) exceed maximums recommended by USFWS.	–	–	–	–	–	–	–	–
-	**V-Rack with New Downstream Bypass Structures**	This was eliminated based on CFD modeling completed at West Enfield which showed uneven flow distribution. This would likely be exacerbated by the significantly different sized units at Brunswick.	–	–	–	–	–	–	–	–
-	**Behavioral Deterrents**	These were eliminated due to the experimental nature of these products and limited field success.	–	–	–	–	–	–	–	–
-	**Klawa / Low Flow Bypass (For DS Eel Passage)**	This was eliminated since this technology is still experimental and field studies to date have shown low effectiveness.	–	–	–	–	–	–	–	–
-	**Conte Air Lift Bypass (For DS Eel Passage)**	This was eliminated since this technology is still experimental with limited field use and testing.	–	–	–	–	–	–	–	–