Technical Memorandum 2.1 – Concept Design Plans and Cost Estimates
Fir Island Farm Snow Goose Reserve Restoration Feasibility Study
Fir Island, Washington

March 15, 2001

Submitted To:
Mr. Brian Williams
Washington Department of Fish and Wildlife
P.O. Box 1100
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By:
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21-1-12318-002

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GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

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March 15, 2011

Mr. Brian Williams
Washington Department of Fish and Wildlife
P.O. Box 1100
La Conner, WA 98257

RE: TECHNICAL MEMORANDUM 2.1 – CONCEPT DESIGN PLANS AND COST ESTIMATES, FIR ISLAND FARM, SNOW GOOSE RESERVE RESTORATION FEASIBILITY STUDY, FIR ISLAND, WASHINGTON

Dear Mr. Williams:

This technical memorandum describes the concept design plans, description of project elements, assumptions of likely construction methods, and the associate probable cost estimates for the Fir Island Farm, Snow Goose Reserve, Restoration Feasibility Study. The concept design plan and cost information are being used in conjunction with other feasibility study alternatives evaluation metrics (such as identifying the areas of restored marsh, predicting juvenile Chinook habitat smolt production from these areas, determining the loss of farmland, etc.) to assess, compare, and select a recommended restoration plan for the project.

PROJECT ALTERNATIVES

Six restoration concept design alternatives have been developed for the project. The major feature involved with a majority of the project includes dike (levee) setback to restore current farm areas back to saltwater tidal marsh. A few alternatives examine replacement of existing top-hinged tidegates with side-hinged, self-regulating tidegate (SRT) structures to allow for partial tidal inflow to interior drainage channels that would also provide some level of tidal marsh restoration. The six alternatives are described as follows:

- Alternative 0: This alternative represents the baseline, existing conditions including tidal marsh, tidal channels, interior drainage channels, farm areas, levees, and parking areas (Figure 1).
- Alternative 1: The project includes a 203-acre increase of tidal marsh areas from a flood dike setback, tidal channel habitat restoration, replacement of interior drainage storage, installation of new overflow floodgates, farm conversion to marsh areas and

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for dike setbacks, parking lot removal and relocation, and replacement of tidegates with similar top-hinge drainage structures (Figure 2).

- Alternative 2: The project includes a 145-acre increase of tidal marsh areas from a flood dike setback, tidal channel habitat restoration, replacement of interior drainage storage, installation of new overflow floodgates, farm conversion to marsh areas and for dike setbacks, and replacement of tidegates with similar top-hinge drainage structures (Figure 2).
- Alternative 3: The project includes a 72-acre increase of tidal marsh areas from a flood dike setback, tidal channel habitat restoration, replacement of interior drainage storage, installation of new overflow floodgates, farm conversion to marsh areas and for dike setbacks, and replacement of tidegates with similar top-hinge drainage structures (Figure 3).
- Alternative 4: The project is located along Dry Slough and includes replacement of two top-hinge tidegates with a pair of SRTs, combined with a low berm (dike) for tidal inflow flood protection, and conversion of farm areas for berm construction (Figure 3).
- Alternative 5: The project is located along Claude O. Davis Slough and includes replacement of two top-hinge tidegates with a pair of SRTs, combined with a low berm (dike) for tidal inflow flood protection, and conversion of farm areas for berm construction (Figure 4).
- Alternative 6: The project is located at Browns Slough and includes replacement of T top-hinge tidegates and a single screw-gate with a set of three SRTs (Figure 4).

CONCEPT DESIGN SCHEMATIC PLANS AND DETAILS

In developing the concept design plan alternatives, some basic schematic designs of primary project components were developed for generic use in similar alternatives. Alternatives 1 through 3 (dike setback alternatives) have similar features and Alternatives 4 through 6 (SRT alternatives) have similar features. We therefore break out the design schematics in accordance with those two general categories and provide descriptions of the key features for each “type” of restoration alternative. A summary of the project alternatives features is enclosed in Table 1.

NEW DIKE SETBACK DESIGN DESCRIPTION (ALTERNATIVES 1 THROUGH 3)

The new dike setback design alternatives each have the following major project elements:

- New dike setback
- Existing dike removal and borrow ditch fill
- Interior drainage tidegates and pipe replacements
- Interior drainage storage area offsets

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- Flood return structure
- Parking lot and trail relocation (Alternative 1 only)

The new dike setback designs include the following descriptions and assumptions related to the design configurations that were used in determining quantities and developing cost estimates.

- Dike flood protection structure setback – The Fir Island Farm Dike is owned and maintained by Skagit County Diking District No. 22 (DD22). In accordance with our interviews with DD22, the dike design will follow the guidelines for the Natural Resources Conservation Service (NRCS), engineering guidelines for marine dike construction (NRCS, 2008). DD22 is in the U.S. Army Corps of Engineers' (USACE's) PL84-99 program, but only for the river levees, not coastal flood protection dikes. The coastal flood protection dikes are subject to NRCS design guidelines and funding assistance, and not subject to USACE's design guidelines or requirements.

  Using the NRCS guidance, the dike structure is classified as a Class II dike, with tidal flood water depths of up to 12 feet above the ground surface. The structure protects agricultural areas with medium to high production, and infrastructure including farmstead and other related facilities. A distinction between a Class I and Class II dike is that overtopping or failure of a Class I dike would result in a possible loss of life. Considering the current dike overtops and floods interior farm areas with no evidence of major threats to public safety or loss of life, the dike system falls within a Class II category.

  The following design criteria were utilized for the Fir Island Farm preliminary plans (with NRCS criteria highlighted in **bold**).

  Using the Class II category, the NRCS design guidance provides the following criteria for dike design (Figure 5):

  – Alignments – Alignments were selected using site LiDAR and existing drainage features (such as the vegetation line of Dry Slough along the Hayton Farm for the east dike toe starting point) to identify logical locations for each of the three setback alternatives (Figures 1 through 3). The southeast corner of the dike is the sharpest angle, which will likely require rock protection.

  – Height – **The design height should be the design high water plus either wave height or freeboard (whichever is greater).** The observed extreme high tide is estimated approximately 13.0 feet North American Vertical Datum of 1988 (NAVD88) (Shannon & Wilson, 2010a). Wind direction data indicates that the site is subject to wave fetch lengths affected by southeastern wind. A fetch length of three miles was measured from the Skagit Delta, Stillaguamish West Pass area to the marsh vegetation line at the Fir Island Farm site. **A Class II dike wind speed requirement of 75 miles per hour with the 3-mile fetch length gives a wave height of 3.8 feet**.

Accommodations and reductions can be made (in accordance with the NRCS guidance) if the dike is protected by vegetation, wood, barriers, or bars which would reduce the height of the wave. This will likely be the case for Fir Island, as the existing marsh vegetation and large wood debris deposits along the Bay Front area will likely influence and reduce wind waves. Using this logic, the fetch length would then be reduced to the area behind (to the north) of the existing marsh. This is a reduced fetch of approximately 0.7 mile. Using this approach, the design wave height is slightly less than 3.0 feet. The wave height design does not include wave run-up estimates due to compression of the wind wave on the face of the dike structure.

An additional consideration to dike design height is long-term sea level rise (SLR). SLR projections for the Puget Sound area range from 3 to 22 inches by 2050 to 6 to 50 inches by 2100 (Mote and others, 2008), considering SLR will affect the design criteria for dike setback profile elevations. The mid-point for the 2050 projection is approximately 1.0 foot.

For the purposes of this study, we recommend a preliminary dike design height using the combination of extreme observed high tide 13.0 feet (NAVD88), plus 3.0 feet to account for wave heights (with reductions for vegetation and wood) and a 1.0-foot addition to account for long-term SLR, resulting in a design height of 17.0 feet (NAVD88).

Note: Other design considerations such as storm surge and tsunami protection are not included in this feasibility study plan evaluation. Also of note, the Wiley Slough dike design elevation was 16.0 feet.

  - Top width **– 15 feet** (**in accordance with NRCS, 2008** and DD22 request)
  - Sideslopes **– 3 Horizontal to 1 Vertical (3H:1V) or flatter (in accordance with NRCS, 2008)** as well as the recommendations provided in the Geotechnical Memo 1.3 (Shannon & Wilson, 2010b).

- Settlement **–** Initial geotechnical investigations indicate that the dike settlement will be on the order of approximately 1 foot (Shannon & Wilson, 2010b). The cost estimate uses a settlement of 2 feet to be conservative, due to the minimal level of geotechnical studies performed to date.
- Erosion protection **–** The preliminary alternatives design assumes that 25 percent of the dike is protected by 2-foot-diameter rock facing and scour protection along the bayward side of the dike (Figure 6). If the entire length of the dike requires rock protection, the cost estimates provided in this memorandum will be significantly less than those if rock is place along 100 percent of the structure length. A number of design considerations need to be evaluated prior to determining the exact extent of rock protection and the 25 percent placeholder is used as an estimate of the amount of existing dike that has rock protection.

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- Seepage cutoffs – Seepage cutoffs are recommended by the design guidance and are included in this alternatives analysis (central cutoff trench) so that some level of seepage design is included as a potential cost item. However, the underlying soils are mainly comprised of deep layers of fine sands. It is not likely that a traditional clay cutoff trench (6 feet wide by 6 to 8 feet deep) running along the toe or center of the levee would be effective in reducing under-seepage. Significantly deeper cutoffs (such as sheet piles or slurry cutoff walls, or other seepage protection measures) would likely be needed if seepage design is under consideration (Figures 5 through 7). For the purposes of developing preliminary cost estimates, we have included the typical cutoff trench, as the exact needs for seepage protection have not been finalized at the time of this memorandum.
- Repair of existing dikes – For Alternative 2, the existing dike will be removed in its entirety. For Alternatives 1 and 3, a portion of the existing dike will not be removed and will need repair to maintain a level of protection similar to the new dike. Costs are included for repairing and replacing certain sections of dike for Alternatives 1 and 3.
- Import materials – We assume 100 percent use of import soils due to the underlying sand layers at the project site. The import soils will likely consist materials that could be classified as GM (silty gravels, gravel-sand-silt mixtures), GC (clayey gravels, gravel-sand-clay mixtures), SM (silty sands, sand-silt mixtures), SC (clayey sands, sand-clay mixtures), and, possibly, ML (inorganic silts of low to medium plasticity, rock flour, sandy silts, gravelly silts, or clayey silts with slight plasticity) soils. We have assumed an import price of $10 per cubic yard (cy) based on average bids from the Fisher Slough project. However, it is noted that more recent bids for soil import approximately $15/cy. A $5/cy increase in import price would raise the cost of the project significantly.
- Topsoil – The dike design assumes a 6-inch layer of topsoil will be placed and hydroseeded on both the waterward and landward sides of the dike, for the entire length of the setback dike.
- Road surfacing – A 3-inch-thick subgrade and 3-inch-thick crushed rock surfacing materials will be used along the dikes to provide access.

Existing Dike Removal

The existing dike will be removed and excavated down to match existing marsh grade (for the exterior marsh) and will include stripping of all topsoil and rock, and salvaging materials as feasible (Figure 8). The existing dike fill will be used to fill in the adjacent borrow ditches that parallel the existing structure. At the December 2010 steering committee meeting (Washington Department of Fish and Wildlife [WDFW], Barnard) asserted that filling of the borrow ditches was a preferred construction approach versus a dike breaching approach. If existing materials are found to be suitable, they will be considered for use in construction of the new dike. However, reuse of existing dike soils is not likely feasible due to the sequencing constraints of building and removing a dike in a tidal area. Also, it is likely that a large quantity of fill material will be necessary to fill the borrow ditches.

Interior Drainage Storage Channels and Ponds

Each of the dike setback alternatives include interior drainage storage channels designed to be equivalent in size to the amount of existing interior drainage storage channels that will be converted (removed) to habitat channels (Figure 9). The interior drainage storage areas sizes vary for each alternative. We assume that the interior drainage storage areas will be excavated to a depth of 6 feet, similar to the channel the depth of the No Name Slough drainage channel and that the channels are approximately 50 feet wide, with their length varying to match the reduction in interior storage drainage area.

Interior Drainage Storage Tidegates and Pipes

For the dike setback alternatives, the project assumes removal and replacement of existing tide gates (top hinge flapgates) in new locations along the new dike setback (Figure 10). This element of the project includes full removal and disposal of existing tidegates and pipes, which will then be fully replaced in-kind with similar drainage structures at a new location along the dike setback alignment. Trash racks will be included with the project to protect the tidegates from wood debris damage. Construction methods assume simple dewatering using aggregate bags and sump pump systems out of the influence of tidal fluctuations.

Flood Return Structure

DD22 has requested that a flood return structure be included in the new dike setback (Figure 11). We assume this will be similar to the flood return structure on the north levee of Fisher Slough which has eight, stainless steel, 36-inch-wide by 60-inch-tall (3 feet by 5 feet) flapgates affixed to concrete headwall structure.

Channel Dredging and Pilot Channel Excavations

Dredging of Dry, Claude O. Davis, and No Name Sloughs is being considered as a potential option for upsizing the channel due to historic filling (especially with respect to Dry Slough). Initial analysis of the current channel cross section sizes was compared with predictive morphology that would evolve under a restored condition for the dike setback project. The analysis indicates that for Dry and No Name Sloughs the existing channels are likely larger than

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would naturally evolve as a result of the dike setback project. Claude O. Davis is likely smaller than would evolve and, therefore, dredging is considered a project option for this feature for Alternatives 1 through 3.

Pilot channel excavations include excavation of secondary tidal channels laterally away from Dry, Claude O. Davis and No Name Sloughs to "jumpstart" development of a dendritic tidal channel network.

Marsh Restoration Area Plantings and Seeding

The current project alternatives cost estimates do not include native marsh plantings or seeding and assume that the Bayward seed sources are adequate to establish new marsh areas upon breaching the existing dikes. One consideration for establishing the new marsh vegetation in the restoration areas would be to time the dike breaches and removal such that they occur at the same time as the native marsh vegetation seed drop and release occurs. A vegetation management plan will be developed during the engineering phase of the project to address native seed establishment, and invasive species management-related issues. If large acreages of native marsh seed were to be planted in advance of the dike breaches, the cost associated with collecting and planting native seed could be significant.

Parking Lot and Trail Relocation

For Alternative 1, the parking lot and trailhead area will be relocated to the northwest corner of the new dike setback alignment. All other alternatives do not affect the parking and viewing areas.

SELF-REGULATING TIDEGATES (SRT) DESCRIPTIONS (ALTERNATIVES 4 THROUGH 6)

The SRT alternatives (4 through 6) each have the following major project elements:

- Existing tidegate removal and replacement with SRTs.
- Berm construction (shorter than the dike setbacks) to provide interior storage and flood protection for operation of the SRTs.
- Interior drainage storage area offsets similar to those described for conversion of existing interior drainage channels to channels that will be more frequently inundated by SRT operation.

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Existing Tidegate Removal and Replacement with and Self-regulating Tidegates (SRTs)

Each of the Alternatives 4 through 6 include removal and replacement of existing tidegates with SRTs (Figure 12). The removal of the existing tide gates will include full removal and disposal of all existing structures. New SRT structures will then be installed at the downstream end of the alternatives drainage locations. For the purposes of this study, we have assumed that the SRTs are linked arrays, which means that closure of the gates is tied to a single float or regulating mechanism. Linked arrays are slightly more expensive, but eliminate opening and closure issues when the gates do not operate as a system. Trash racks will be included with the project to protect the tidegates from wood debris damage. Construction assumptions include full sheet pile dewatering and vacuum wellpoint systems to provide full dewatering in high groundwater and tidal influenced area.

Berm Construction Associated with Self-regulating Tidegate (SRT) Replacement Alternatives

For the SRT project Alternatives 4 and 5 (Dry Slough and Claude O. Davis Slough), a flood berm is included in the design to allow for flood protection due to the more frequent inundation of the tidal drainage channel as a result of the SRT installation and operation (Figure 13). The Dry Slough report berm was designed to an elevation of 10.0 feet MLLW (Moffat & Nicholl, 2008), which corresponds to a project berm elevation of approximately 7.4 feet (NAVD88). This elevation appears to be low, considering that existing farm elevations along the berm alignments range from 5 to 7.5 feet. For the purposes of this study, we assumed a 3-foot-high berm with a top width of 15 feet and sideslope of 3H:1V.

COST ESTIMATE AND ASSUMPTIONS

Preliminary estimates of the project's probable costs were developed for each of the project alternatives (Table 2). Development of the cost estimates uses the following methods and assumptions:

- Quantity takeoffs were determined using end-area methods for all major earthwork items, and not digital terrain modeling. Digital terrain surface modeling will be used in the final engineering phase of work to refine earthwork quantities.
- The cost estimate uses 2011 RS Means unit prices (unadjusted for Washington as Mount Vernon, Skagit County, prices are near the United States mean pricing index (RS-Means, 2011a and 2011b). Local unit prices for soil import and aggregates prices used the Fisher Slough 2010 average bid prices.
- A 7.8 percent tax was applied to the construction costs.

- Construction contingencies for this phase of study were assumed to be 25 percent. Major contingencies and potential risks for changes in cost, known at the time of this cost estimate, are:
  - Soil import prices. The Fisher Slough average bids were $9.42/cy. A more recent follow-up bid indicated that prices may have escalated to $15.00/cy due to changes in market conditions and soil suppliers pricing the market for new levee projects. A price increase for soil import from $9.42/cy to $15.00/cy could increase the cost of a project alternative by more than $1,000,000. We recommend considering separate soil import bidding and procurement (to be delivered by WDFW – the Owner) to ensure fair bidding and limit markups on this particular large-cost item.
  - Cultural resources and archaeological discoveries during engineering design or construction phases could create significant additional costs to the project due to the additional study and mitigation requirements of the project.
  - Rising gas prices and changes in economic conditions beyond 2011 (economic rebound) could increase costs significantly. Recent construction bids in the Puget Sound area have been low due to current depressed economic conditions. If the market rebounds, then prices will increase accordingly.
  - We recommend developing a future value cost estimate at the time of grant submittal to estimate project cost at the time of construction.
  - A list of potential construction contingencies (such as delays due to wet weather, cultural resources, other) should be performed during the engineering design phase prior to construction contracting to better understand overall project costs and risks for cost increases.
  - Pump stations and other “extraneous” interior drainage infrastructure costs have not been included, that may be necessary as drainage improvements.
  - Project contingencies regarding private landowner and public input processes necessary to allow the project to move forward could require significant resources due to the scope and size of the project and the current perceptions of this type of project in the Skagit Delta. This comment should be taken under consideration in scoping and funding the final public outreach and permitting phases of the project.
- Project costs include construction cost estimates, plus the following additional costs:
  - Real estate costs:
    - Real estate acquisition based on cost/acre ($8,200/acre) provided by WDFW assessors.
    - Construction easements were assumed to be $1,500/acre for one season easement.

    - National American Wetlands Conservation Act (NAWCA) reimbursements to offset Snow Goose Reserve grant money, as provided by WDFW.
  - Engineering design costs – Assumed 8 percent of construction costs.
  - Permitting – Assumed 2 percent of construction costs.
  - Project Administration of Engineering and Permitting – Assumed 10 percent of Engineering Design and Permitting Costs.
  - Construction Oversight and Administration Costs – Assumed 10 percent of construction.
  - Note: Engineering design, permitting, project administration, and construction oversight cost estimates using "percentage of construction costs" are placeholders for planning purposes only. Actual costs may be more or less depending upon the actual requirements of the project. We recommend developing a detailed scope of work to be performed for each phase of the project including engineering design, permitting, construction, and monitoring of the project. This information should then be used to revise the enclosed cost estimates and submitted with future grant and funding applications.
- Total Project Capital Costs are assumed to include the total of:
  - Construction costs plus 25 percent contingencies and 7.8 percent tax.
  - Engineering design, permitting, and construction oversight assumed to be approximately 20 percent of construction costs.
  - Real estate acquisition, construction easements, and NAWCA reimbursement costs.

CLOSURE

The conclusions and recommendations documented in this technical memorandum have been prepared for specific application to this project and have been developed in a manner consistent with that level of care and skill normally exercised by members of the environmental science profession currently practicing under similar conditions in the area, and in accordance with the terms and conditions set forth in our agreement. The conclusions and recommendations presented in this technical memorandum are professional opinions based on interpretation of information currently available to us and are made within the operational scope, budget, and schedule constraints of this project. No warranty, express or implied, is made.

Estimates of probable costs are subject to continual changes and fluctuations in market prices, as well as uncertainties associated with vast amount of unknown information for the Fir Island Farm project. We recommend considering the estimate of probable costs as estimates only and as guidelines for likely costs. Cost estimates should be continually updated throughout each phase of the project as it progresses.

We also note that the facts and conditions referenced in this technical memorandum may change over time, and that the facts and conditions set forth here are applicable as described only at the time this technical memorandum was written. We believe that the conclusions stated here are factual, but no guarantee is made or implied.

This technical memorandum was prepared for the exclusive use of WDFW and its representatives and in no way guarantees that any agency or its staff will reach the same conclusions as Shannon & Wilson, Inc.

Sincerely,

SHANNON & WILSON, INC.

David R. Cline, P.E.
Associate

DRC/drc

Enc: References
Table 1 – Alternative Design Information
Table 2 – Fir Island Farm Alternatives Cost Summary
Figure 1 – Alternative 0 (Baseline)
Figure 2 – Alternatives 1 & 2
Figure 3 – Alternatives 3 & 4
Figure 4 – Alternatives 5 & 6
Figure 5 – Typical Section, New Dike Design (Cutoff Trench without Rock Protection)
Figure 6 – Typical Section, New Dike Design (Cutoff Trench with Rock Protection)
Figure 7 – Typical Section, New Dike Design (Slurry Wall Cutoff without Rock Protection)
Figure 8 – Typical Section, Existing Dike Removal and Borrow Ditch Fill
Figure 9 – Typical Section, New Interior Drainage Storage Pond/Channel
Figure 10 – Typical Top-hinge Tidegate
Figure 11 – Typical Detail, Flood Return Gates
Figure 12 – Typical Self Regulating Tidegate (SRT)
Figure 13 – Typical Section, SRT Alternatives Tidal Flood Protection Berm

REFERENCES

Moffat & Nicholl, 2008, Dry slough tidegate replacement, hydraulic and geomorphic assessment.

Mote P.W., and others, 2008, Sea level rise scenarios for Washington State: Report prepared by the Climate Impacts Group, Center for Science in the Earth System, Joint Institute for the Study of the Atmosphere and Oceans, University of Washington, Seattle, Washington, and the Washington Department of Ecology, Lacey, Washington.

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Shannon & Wilson, 2010a, Draft Technical Memorandum 1.1.1: Survey, Washington Department of Fish and Wildlife, Fir Island Farm restoration feasibility study, Snow Goose Reserve, Skagit County Washington.

Shannon & Wilson, 2010b, Draft Technical Memorandum 1.3: Geotechnical Baseline Study, Fir Island Farm restoration feasibility study, Snow Goose Reserve, Skagit County Washington.

Washington Department of Fish and Wildlife, 2005, Wiley Slough Design Report, Final Version 3.1.

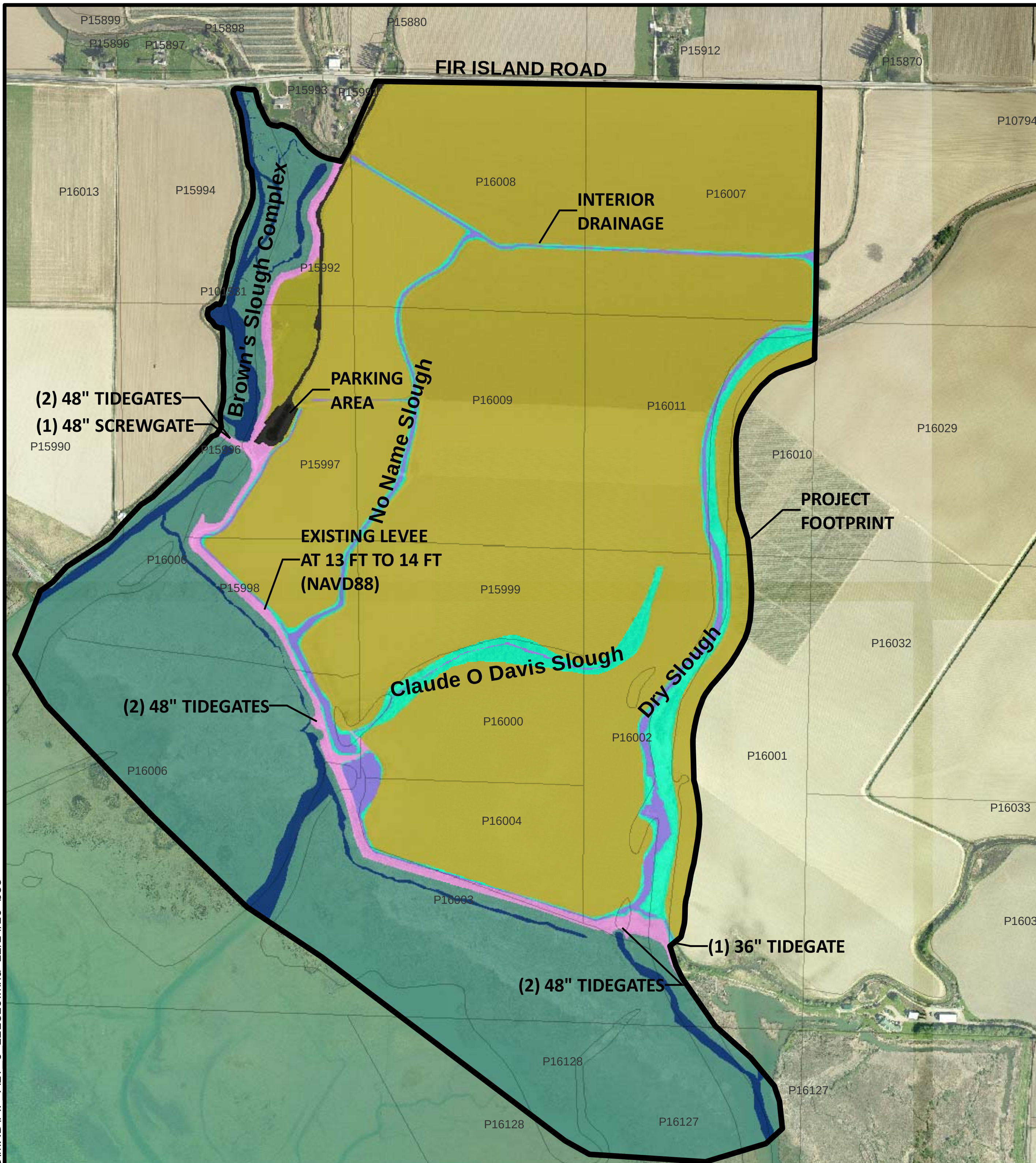
TABLE 1
ALTERNATIVE DESIGN INFORMATION

Alternative	New Dike Setback Length (ft)	Flood Return Gates	Tidegates Replaced	New SRTs	Interior Drainage Storage Area (ac)	Notes
0	—	—	—	—	—	Levee repair likely needed. Cost estimate not developed.
1	8,600	(6) 48-inch Square Flaps	(4) 48-inch Gates (1) 36-inch Gate	—	6.9	—
2	7,360	(6) 48-inch Square Flaps	(4) 48-inch Gates (1) 36-inch Gate	-	6.3	
3	8,200	(6) 48-inch Square Flaps	(4) 48-inch Gates (1) 36-inch Gate	-	4.8	2,000-foot road repair and levee raise required along existing levee connector.
4	7,625	-	(2) 48-inch Gates	(2) 48-inch Gates	2.8	
5	4,725	-	(2) 48-inch Gates	(2) 48-inch Gates	0.6	
6	-	-	-	(3) 48-inch Gates	-	

Notes:
Ac = acre
ft = foot
SRT = Self-regulating tidegates

TABLE 2
FIR ISLAND FARM ALTERNATIVES COST SUMMARY

Description	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Construction Costs	$ 12,654,000	$ 11,716,000	$ 11,016,000	$ 2,688,000	$ 1,638,000	$ 1,385,000
Real Estate Acquisition and Easements	$ 1,729,000	$ 1,274,000	$ 702,000	$ 142,000	$ 61,000	$ -
Engineering Design, Permitting and Construction Oversight	$ 2,404,000	$ 2,226,000	$ 2,093,000	$ 516,000	$ 315,000	$ 266,000
Total Project Capital Costs	**$ 16,787,000**	**$ 15,216,000**	**$ 13,811,000**	**$ 3,346,000**	**$ 2,014,000**	**$ 1,651,000**



Alternative	Project Element	Map Symbol	Existing Area (ac)
0	Levee		7.7
	Habitat Channels		10.3
	Drainage		8.0
	Tidal Marsh		122.1
	Freshwater Wetland		15.1
	Farm		250.1
	Roads		1.6

0 400 800

Scale in Feet

N W E S

State Plane Washington
North 4601 NAD83/NAVD88

Fir Island Farm Restoration
Skagit Snow Goose Preserve
Skagit County, Washington

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ALTERNATIVE 0
(BASELINE)

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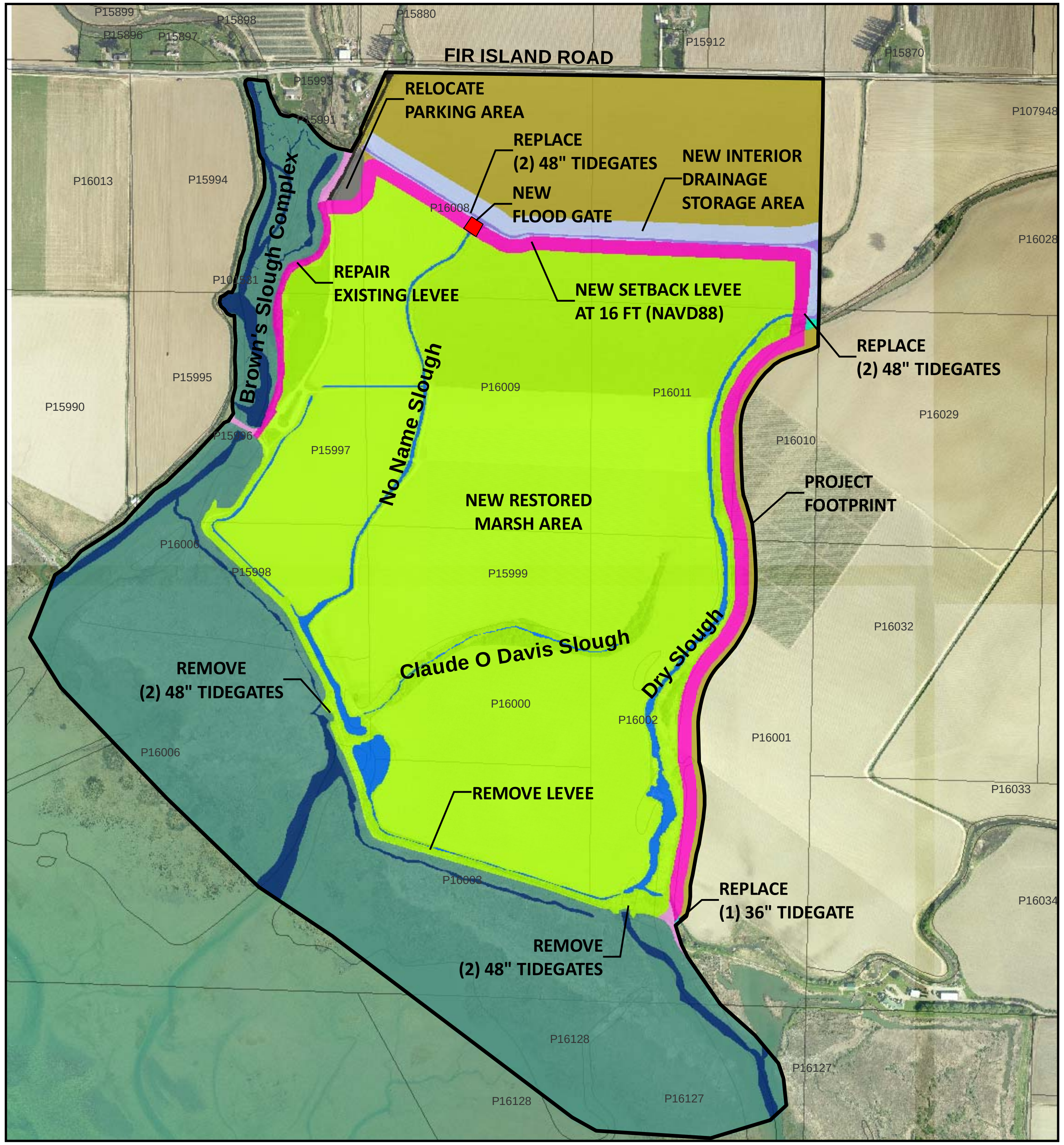
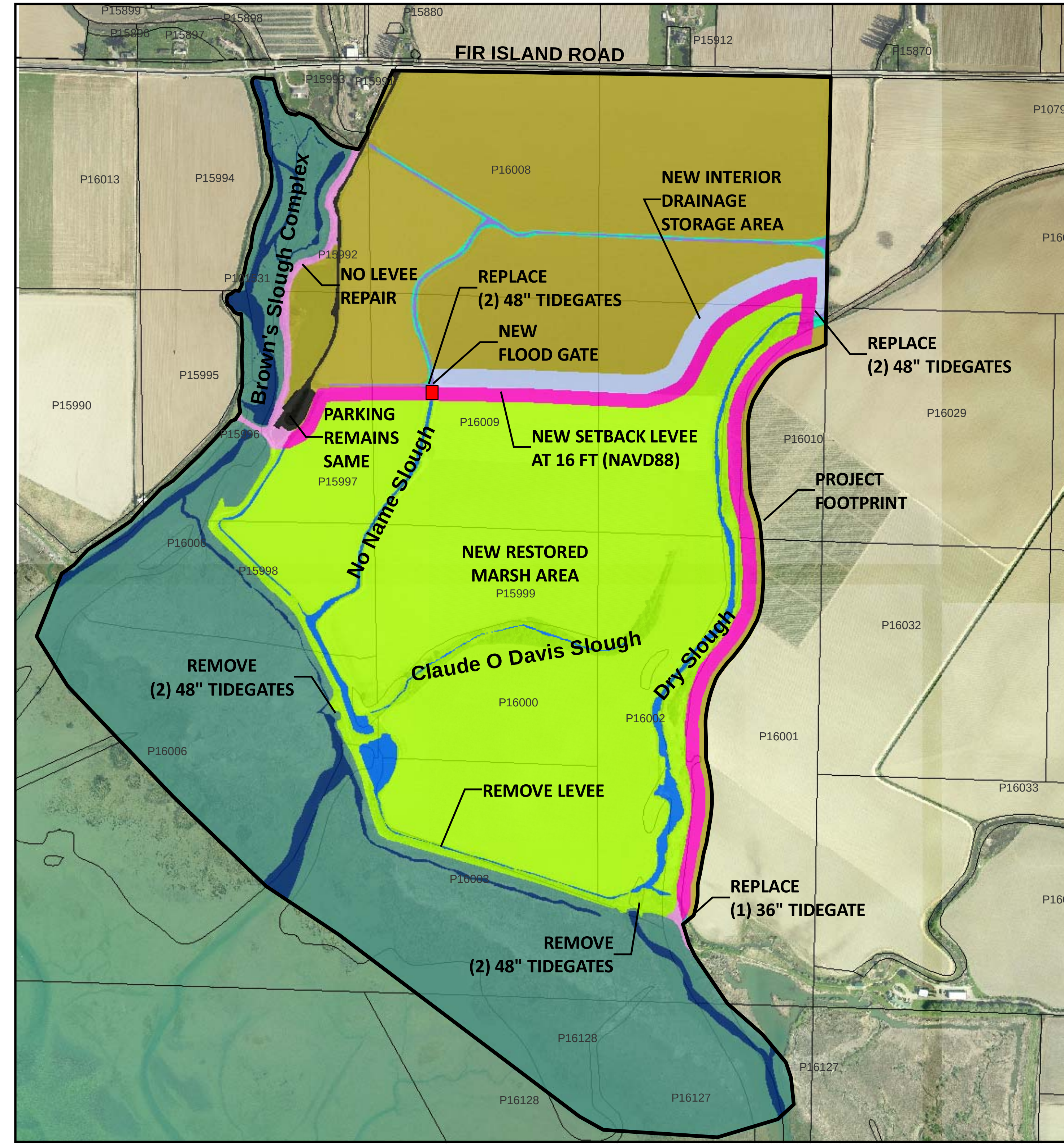
FIG. 1

Filename: I:\WIP\21-1\12318 FIR ISLAND\GIS\MXD\FIF_ALT_0_121310.mxd 12/14/10 beo





Alternative 1

Project Element	Map Symbol: Existing	Map Symbol: New	Area (ac): Existing	Area (ac): Net Change	Area (ac): Total
Levee			7.7	7.7	15.4
Habitat Channels			10.3	6.9	17.2
Drainage			8.0	-	8.0
Tidal Marsh			122.1	202.5	324.7
Freshwater Wetland		NONE	15.1	(14.9)	0.1
Farm		NONE	250.1	(201.5)	48.6
Roads			1.6	(0.6)	1.0

State Plane Washington
North 4601 NAD83/NAVD88

0 400 800
Scale in Feet

Note: Net change in drainage channel is always zero. This includes losses of drainage channels to habitat channel, for which new interior drainage channels are built in kind to offset the loss.

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Alternative 2

Project Element	Map Symbol: Existing	Map Symbol: New	Area (ac): Existing	Area (ac): Net Change	Area (ac): Total
Levee			7.7	8.4	16.1
Habitat Channels			10.3	6.3	16.6
Drainage			8.0	-	8.0
Tidal Marsh			122.1	145.0	267.1
Freshwater Wetland		NONE	15.1	(13.6)	1.5
Farm		NONE	250.1	(146.0)	104.1
Roads		NONE	1.6	-	1.6

Fir Island Farm Restoration
Skagit Snow Goose Preserve
Skagit County, Washington

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ALTERNATIVES 1 & 2

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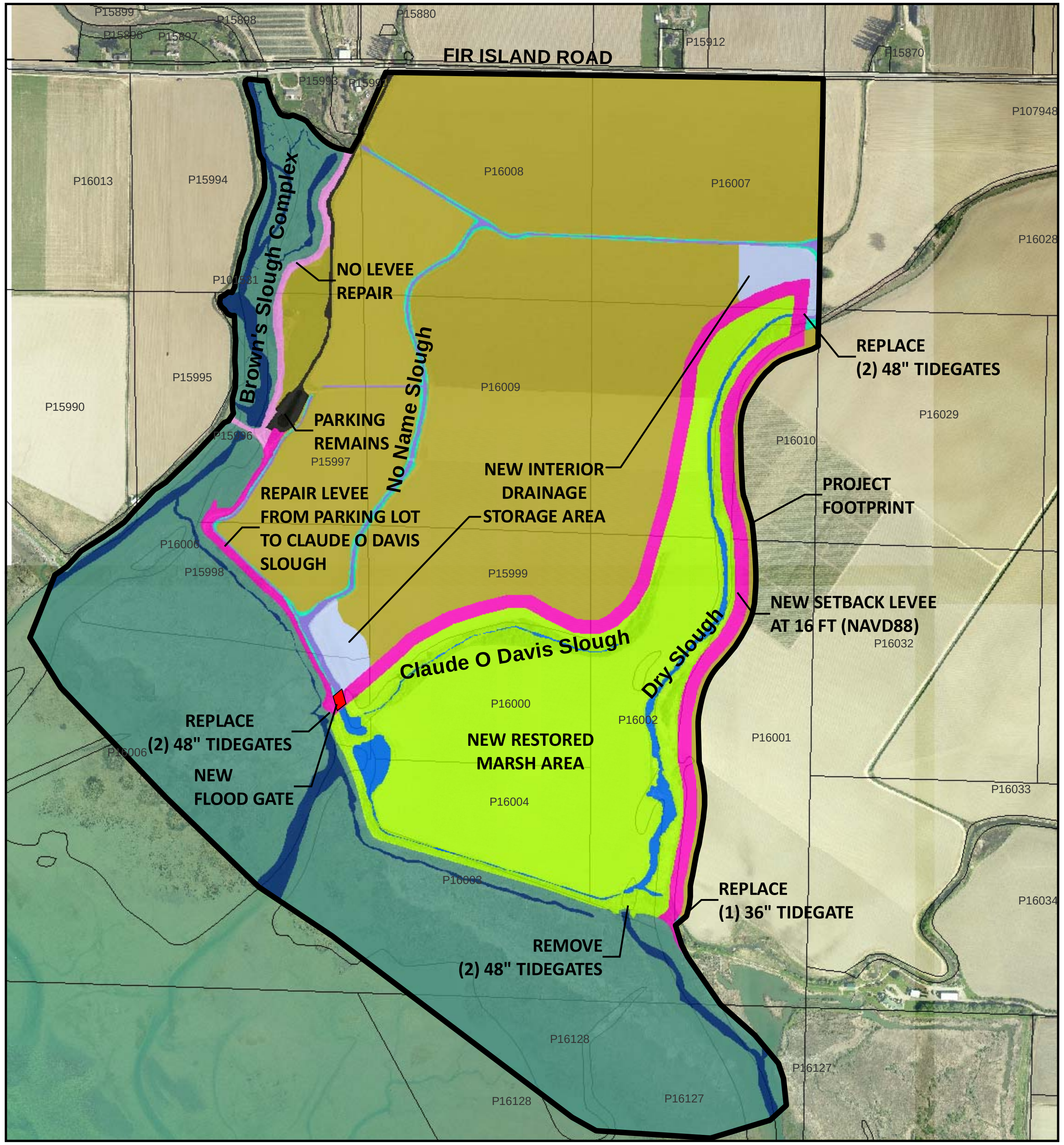
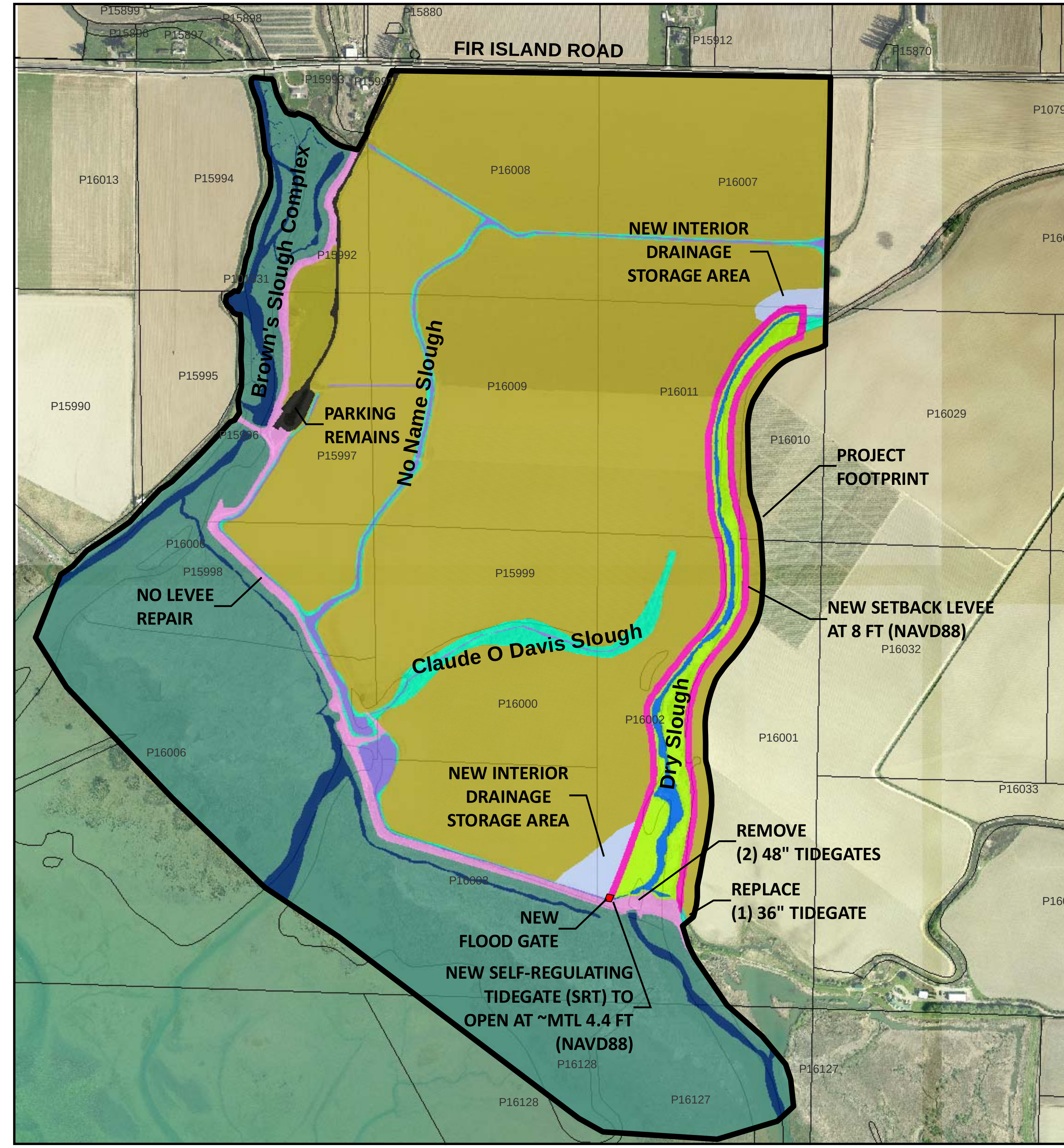
FIG. 2

Filename: I:\WIP\21-1\12318 FIR ISLAND\GIS\MXD\FIF_ALTS_1-2_121410.mxd 12/14/10 beo





Alternative 3	Project Element	Map Symbol: Existing	Map Symbol: New	Area (ac): Existing	Area (ac): Net Change	Area (ac): Total
	Levee			7.7	11.7	19.4
	Habitat Channels			10.3	4.8	15.1
	Drainage			8.0	-	8.0
	Tidal Marsh			122.1	72.3	194.4
	Freshwater Wetland		NONE	15.1	(12.4)	2.7
	Farm		NONE	250.1	(76.3)	173.8
	Roads		NONE	1.6	-	1.6

State Plane Washington
North 4601 NAD83/NAVD88

0 400 800
Scale in Feet

Note: Net change in drainage channel is always zero. This includes losses of drainage channels to habitat channel, for which new interior drainage channels are built in kind to offset the loss.

N W E S

Alternative 4	Project Element	Map Symbol: Existing	Map Symbol: New	Area (ac): Existing	Area (ac): Net Change	Area (ac): Total
	Levee			7.7	7.0	14.7
	Habitat Channels			10.3	2.8	13.1
	Drainage			8.0	-	8.0
	Tidal Marsh			122.1	8.8	130.9
	Freshwater Wetland		NONE	15.1	(7.3)	7.7
	Farm		NONE	250.1	(11.3)	238.8
	Roads		NONE	1.6	-	1.6

Fir Island Farm Restoration
Skagit Snow Goose Preserve
Skagit County, Washington

DRAFT

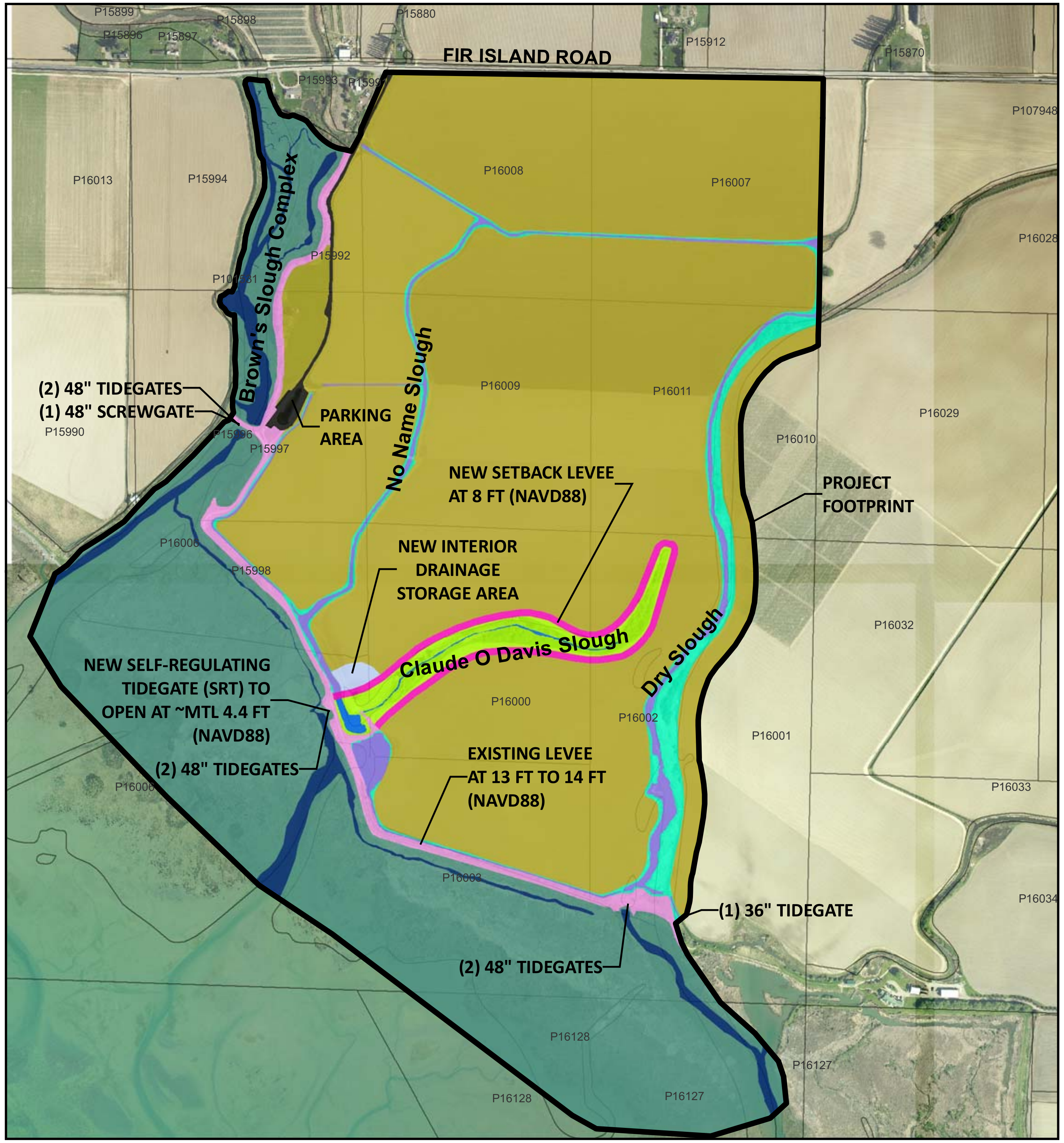
ALTERNATIVES 3 & 4

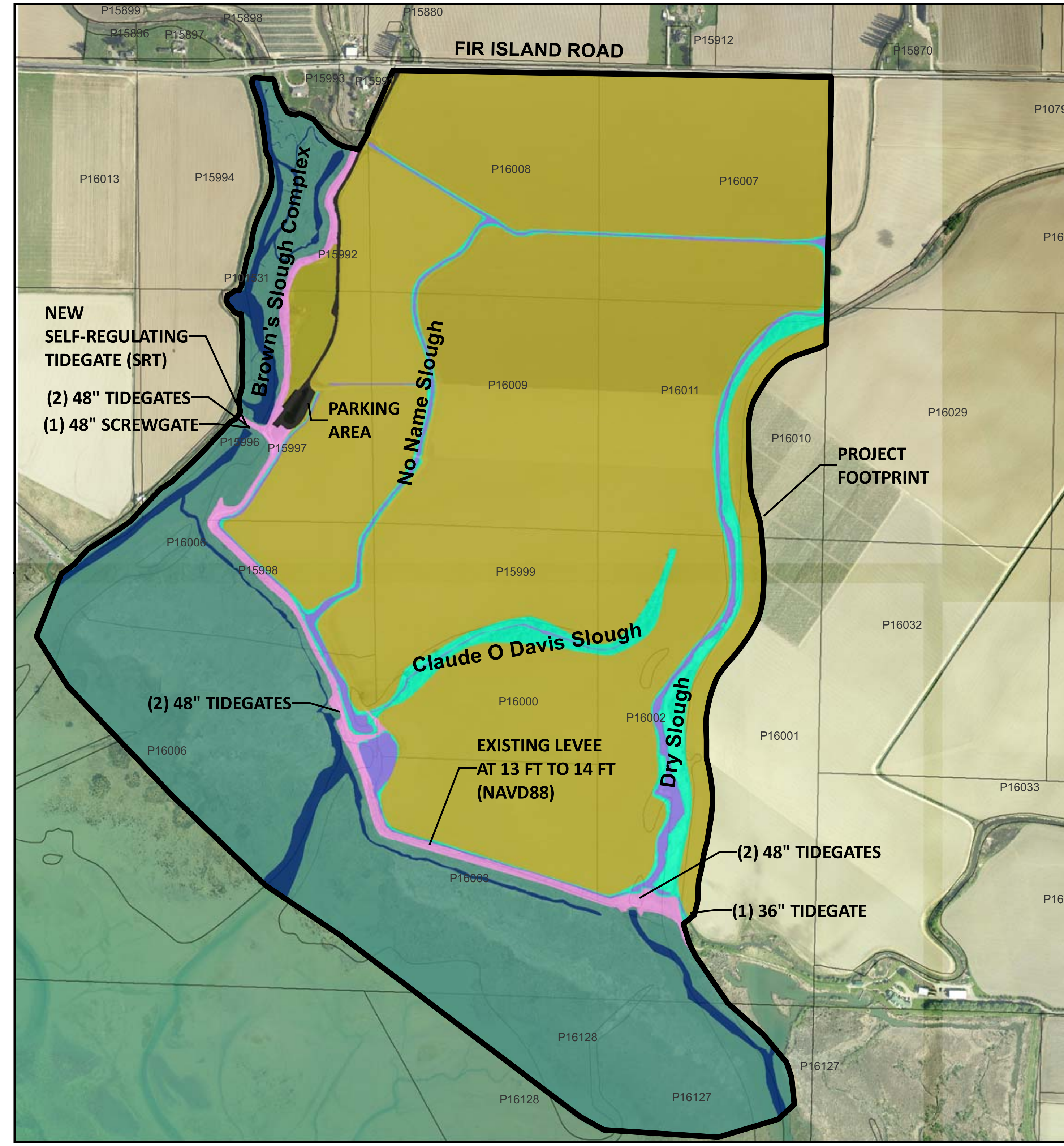
December 2010 21-1-12318-002

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 3

Filename: I:\WIP\21-1\12318 FIR ISLAND\GIS\MXD\FIF_ALTS_3-4_121410.mxd 12/14/10 beo





Alternative 5	Project Element	Map Symbol: Existing	Map Symbol: New	Area (ac): Existing	Area (ac): Net Change	Area (ac): Total
	Levee			7.7	4.3	12.1
	Habitat Channels			10.3	0.6	10.9
	Drainage			8.0	-	8.0
	Tidal Marsh			122.1	7.0	129.1
	Freshwater Wetland		NONE	15.1	(4.6)	10.5
	Farm		NONE	250.1	(7.4)	242.7
	Roads		NONE	1.6	-	1.6

State Plane Washington
North 4601 NAD83/NAVD88

0 400 800
Scale in Feet

Note: Net change in drainage channel is always zero. This includes losses of drainage channels to habitat channel, for which new interior drainage channels are built in kind to offset the loss.

Alternative 6	Project Element	Map Symbol: Existing	Map Symbol: New	Area (ac): Existing	Area (ac): Net Change	Area (ac): Total
	Levee		NONE	7.7	-	7.7
	Habitat Channels		NONE	10.3	-	10.3
	Drainage		NONE	8.0	-	8.0
	Tidal Marsh		NONE	122.1	-	122.1
	Freshwater Wetland		NONE	15.1	-	15.1
	Farm		NONE	250.1	-	250.1
	Roads		NONE	1.6	-	1.6

Fir Island Farm Restoration
Skagit Snow Goose Preserve
Skagit County, Washington

DRAFT

ALTERNATIVES 5 & 6

December 2010 21-1-12318-002

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 4

Filename: I:\WP\21-1\12318 FIR ISLAND\GIS\MXD\FIF_ALTS_5-6_122110.mxd 12/22/10 beo

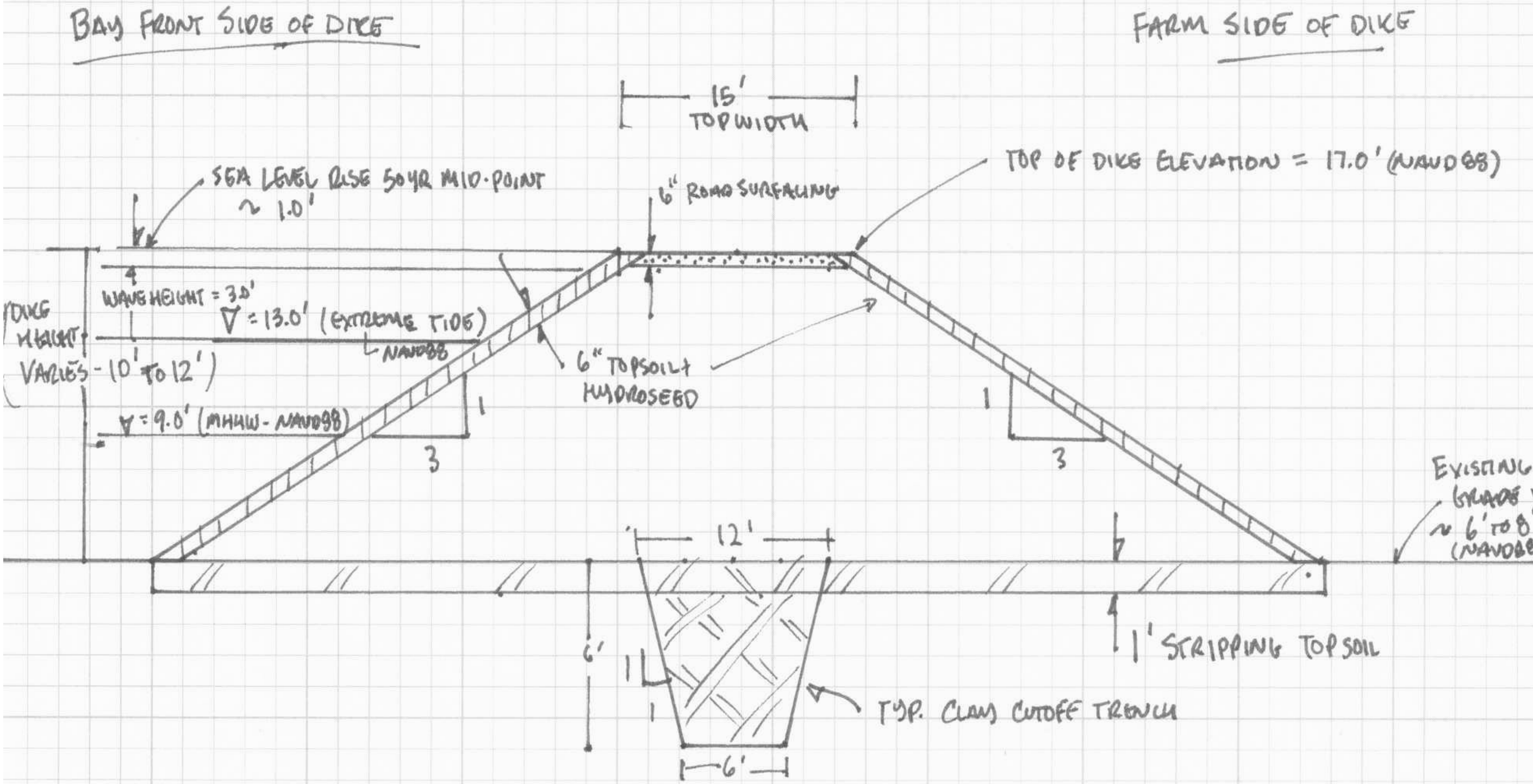


FIGURE 5. TYPICAL SECTION
NEW DIKE DESIGN
(CUTOFF TRENCH W/O ROCK PROTECTION)

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

JOB NAME: Fir Island
SUBJECT: Typ. Sect New Dike w/o Rock
BY: DRC
CHK'D:
JOB NO.: 21-1-12318-003
DATE: 3/14/11
SHEET: 1 of 1

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

JOB NAME Fir Island
SUBJECT Typ. Sect New Dike w/ Rock
BY DRC
CHK'D
JOB NO. 21-1-12318-003
DATE 3/14/11
SHEET of

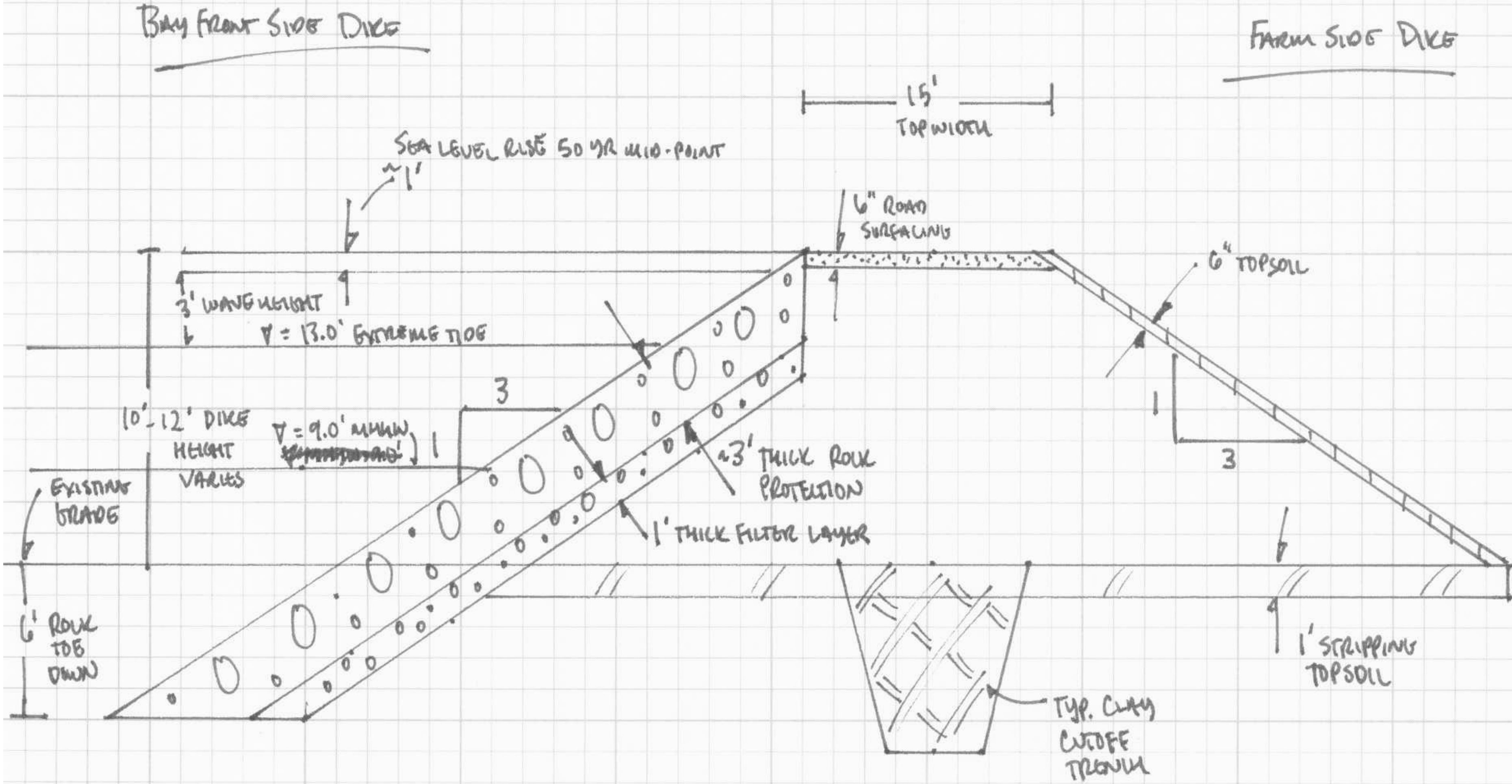


Figure 6. Typical Section New Dike Design (Cutoff Trench w/ Rock Protection)

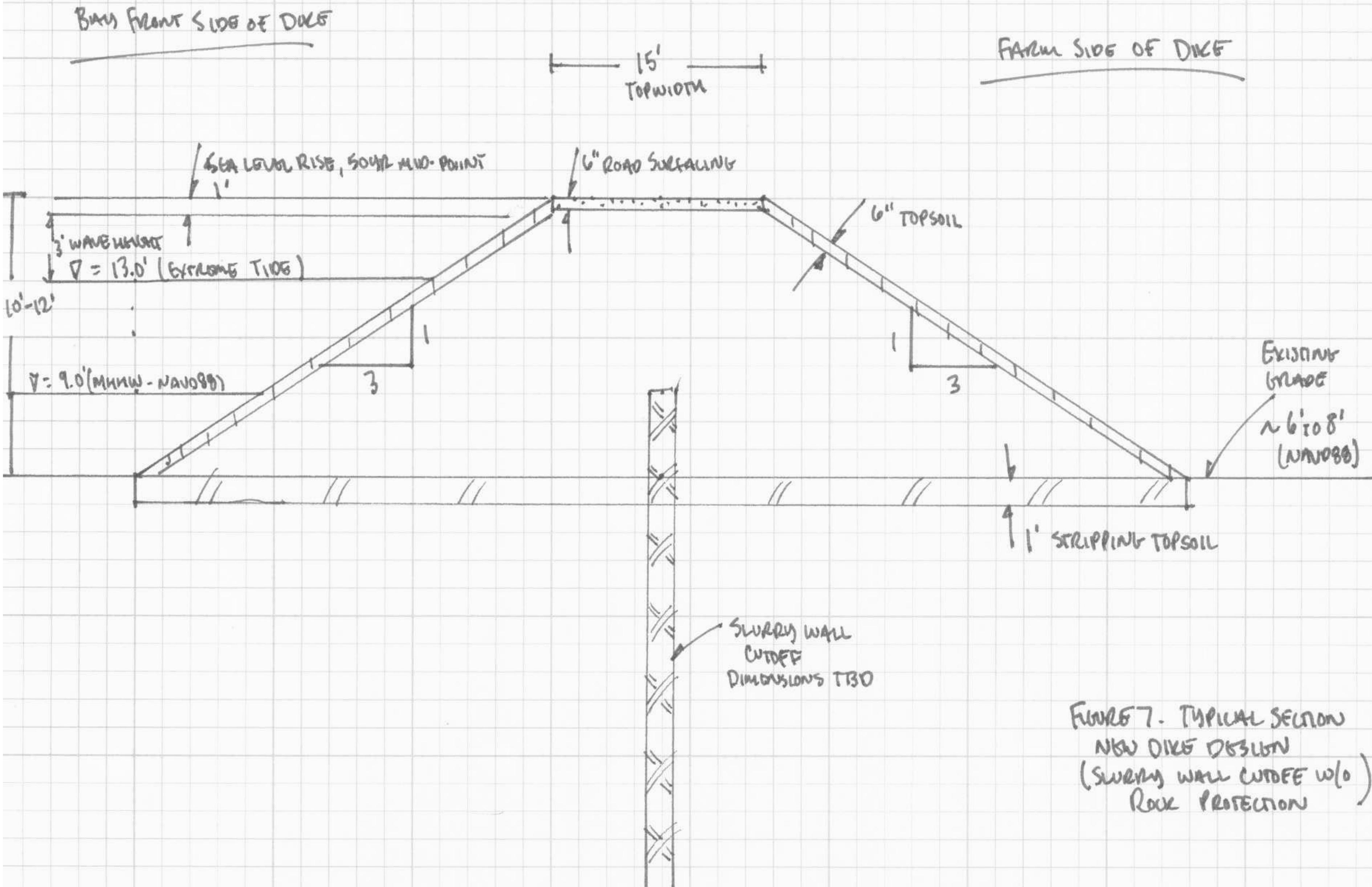


FIGURE 7. TYPICAL SECTION NEW DIKE DESIGN (SLURRY WALL CUTOFF W/O ROCK PROTECTION)

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

JOB NAME Fir Island
JOB NO. 21-1-12318-003
SUBJECT Typ. Sect New Dike Slurry Wall
DATE 3/14/11
BY DRC
CHK'D
SHEET 1 of 1

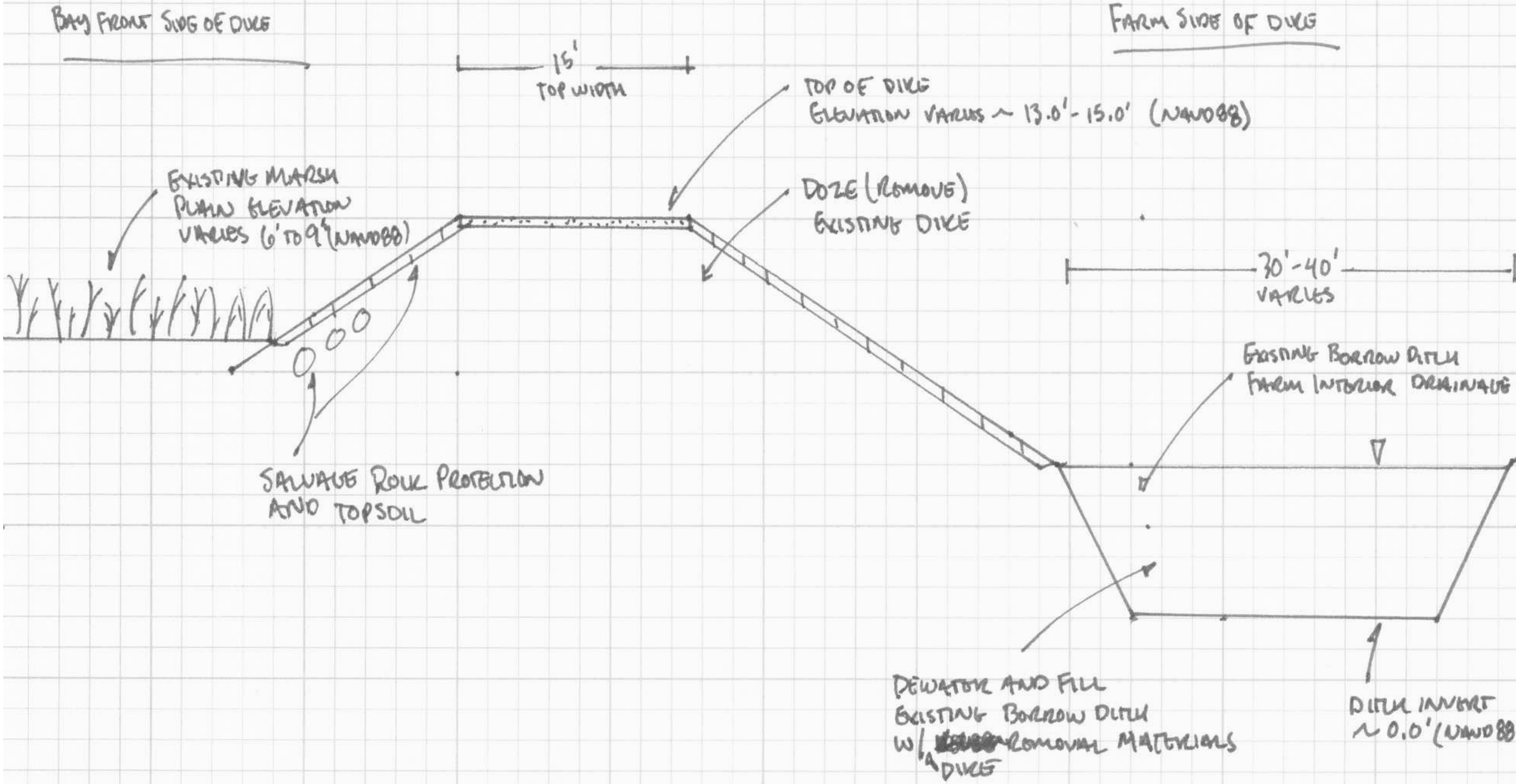


FIGURE 8. TYPICAL SECTION
EXISTING DIKE REMOVAL AND
BORROW DITCH FILL.

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

JOB NAME Fir Island
SUBJECT Typ. Section, Dike Remove, Ditch Fill
BY DRC
CHK'D
JOB NO. 21-1-12318-003
DATE 3/14/11
SHEET 1 of 1

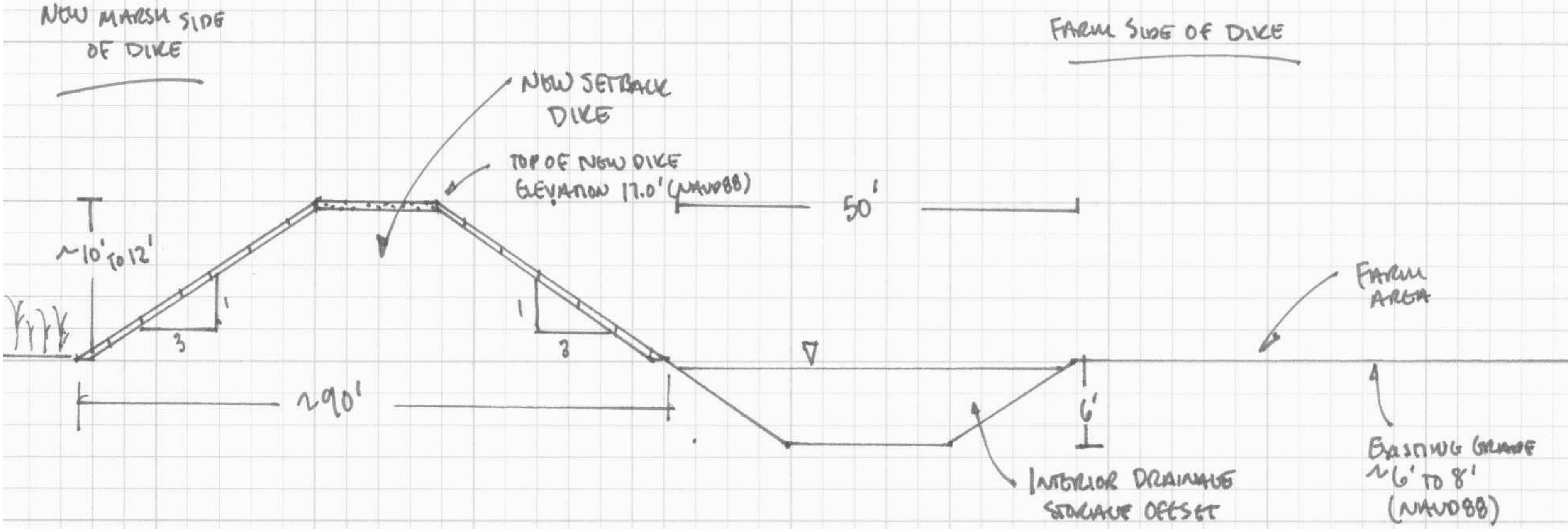


FIGURE 9. TYPICAL SECTION NEW INTERIOR DRAINAGE STORAGE PONDS / CHANNELS

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

JOB NAME Fir Island
SUBJECT Typ. Section, New Dike w/ Interior Storage Pond
BY DRC
CHK'D
JOB NO. 21-1-12318-003
DATE 3/14/11
SHEET 1 of 1

Fir Island Farm Restoration Feasibility Study
Skagit River Delta
Skagit County, Washington

Image Typical
Top-Hinge Tidegate
Browns Slough

March 2011 21-1-12310-001

SHANNON & WILSON, INC
Geotechnical and Environmental Consultants

Fig. 10

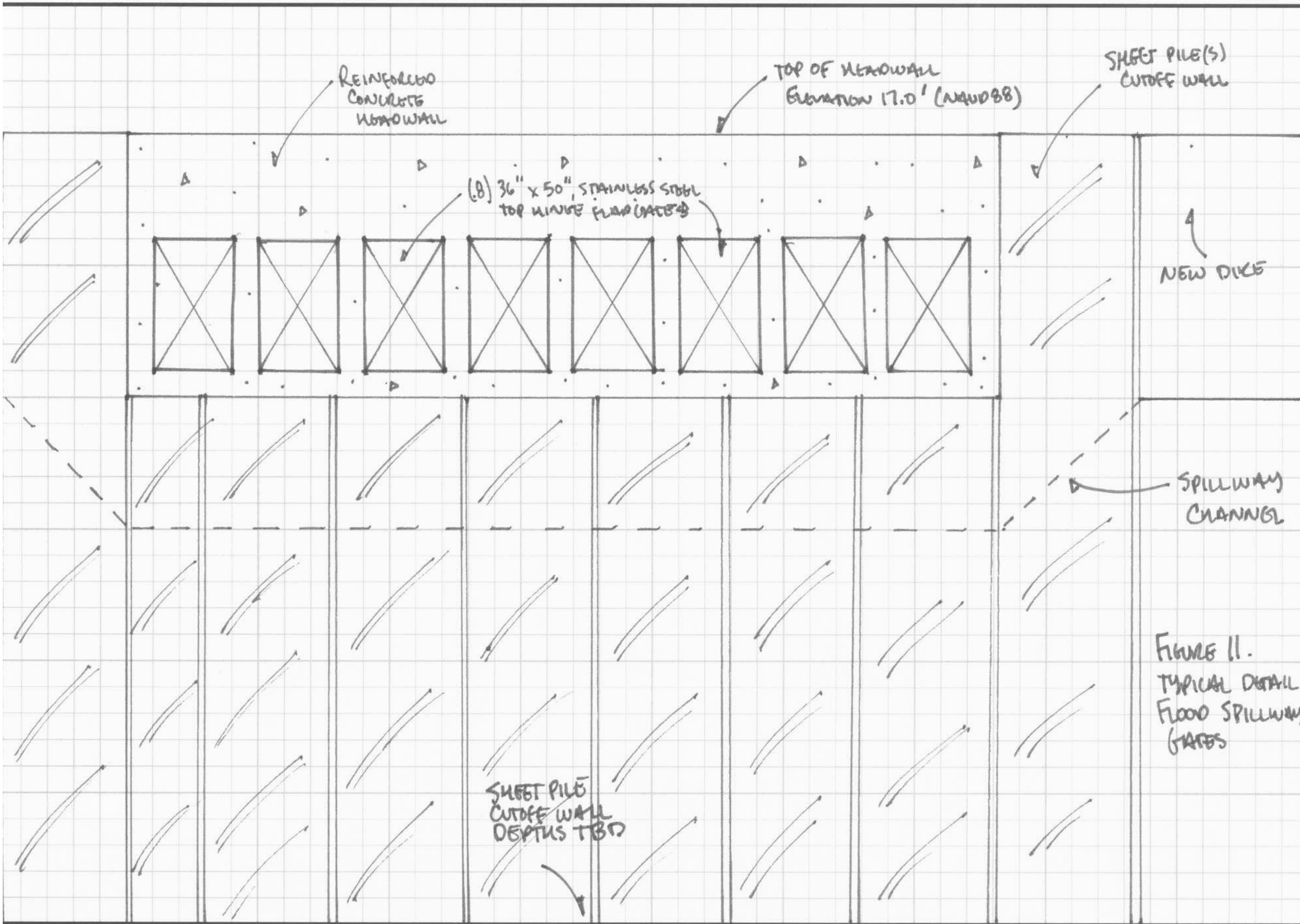


FIGURE 11.
TYPICAL DETAIL
FLOOD SPILLWAY
GATES

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

JOB NAME: FIR ISLAND
SUBJECT: TYP. DETAIL, FLOOD RETURN GATE
BY: DRC
CHK'D:
JOB NO.: 21-1-12318-003
DATE: 3/14/11
SHEET 1 of 1

Fir Island Farm Restoration Feasibility Study
Skagit River Delta
Skagit County, Washington

Images Typical
Self Regulating Tidegate (SRT)

Source: Nehalem Marine Manufacturing

March 2011 21-1-12310-001

SHANNON & WILSON, INC
Geotechnical and Environmental Consultants

Fig. 12

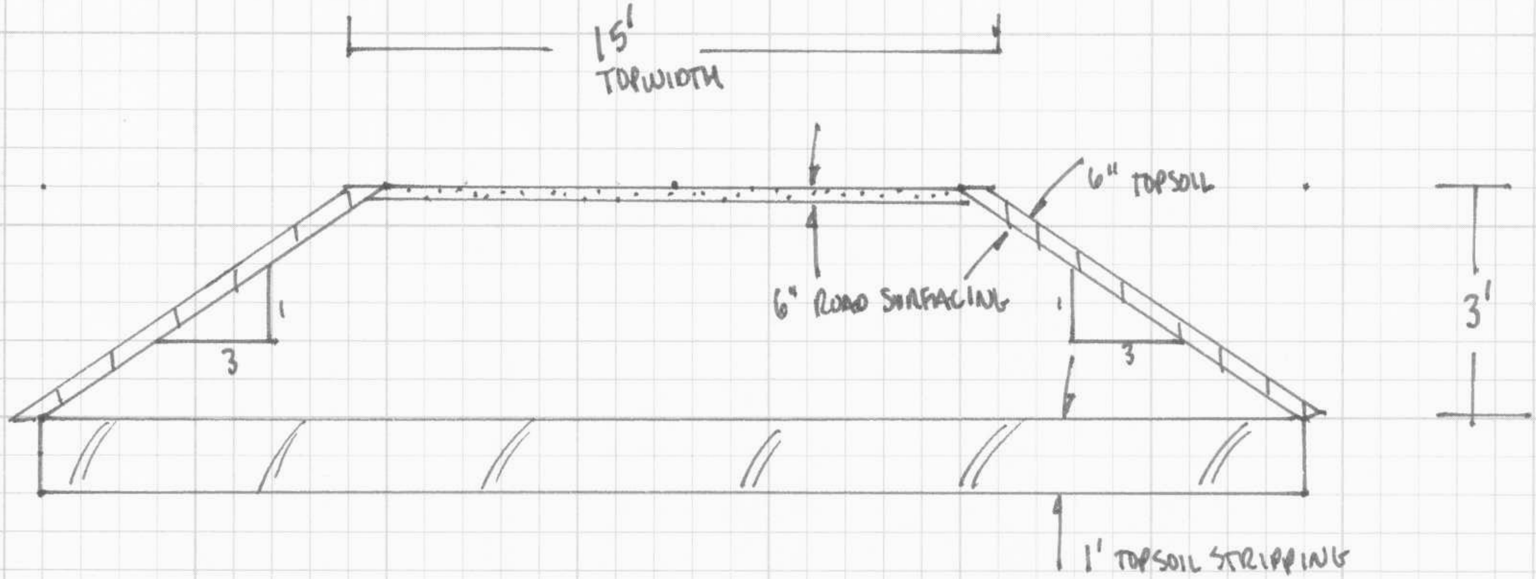


FIGURE 13. TYPICAL SECTION
SRT ALTERNATIVES
TIDAL FLOOD PROTECTION BERM

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

JOB NAME FIR ISLAND
SUBJECT TYP. SECT. SRT FLOOD BERM
BY DRC CHK'D
JOB NO. 21-1-12318-003
DATE 3/14/11
SHEET 1 of 1