Williams Dam

Town of Londonderry

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Introduction

Williams Dam (State ID #115.01) is located on the West River in Londonderry, VT in close proximity to VT Route 11. The State of Vermont completed an inspection of the dam in August 2015, and recommended that the Town of Londonderry (Town) retain an engineer to evaluate the dam. The State recommendations included monitoring erosion occurring on the left abutment of the dam, and the evaluation and preparation of plans to repair, replace, or remove the dam. These recommendations were based upon the observed poor condition of the dam and the potential risk to the stability of the Vermont Route 11 (VT Rte 11) bridge and the downstream inundation area.

In November 2021, the Town authorized a comprehensive study of alternatives for Williams Dam. The Town engaged DuBois & King, Inc., to evaluate the condition of the dam and determine comparative costs for the dam's rehabilitation, replacement, or removal. This evaluation included:

- Inspection of the dam,
- Meetings with Town Staff and State of Vermont Dam Safety engineers,
- Review of available information and records,
- Development of alternatives including conceptual engineering plans and construction cost estimates,
- Evaluation of conceptual alternative permitting requirements, and
- A presentation to the Town.

Dam Description

Williams Dam is a run-of-the-river dam constructed of stone masonry and concrete in the 1800s. A run-of-the-river dam is a structure constructed to impound a portion of a river with the normal flow of water flowing over the dam. Williams Dam was originally constructed to generate power for an adjacent machinery shop.

The dam appears to be founded on bedrock, with stone masonry that was capped in concrete. The dam is approximately 20-ft tall from the downstream toe of the dam to the top of the intake structure and approximately 90-ft long between the abutments. The dam consists of a primary spillway and a low-level outlet structure. The low-level structure contains a 6-foot diameter corrugated metal outlet pipe and vertical slide gate on the upstream side of the structure.

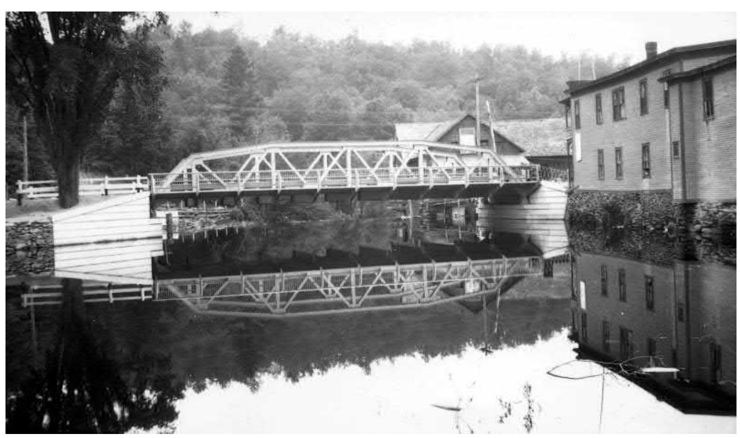
Dam Background & History

The Londonderry Historical Society states that the Town was chartered in 1780, and by the 1800's the Town's population was approximately 1,300 people due to an increase in manufacturing jobs. The Gazetteer and Business Directory of Windham County, VT, 1724-1884, lists several manufacturing businesses from gristmills to a tub factory. A three-story machine shop on Main Street was erected in 1867. In 1883, Mr. Williams constructed a stone dam across the West River for the machine shop.

1908 – Mill Dam, Bridge and Bacon's Store in Londonderry, VT
Source: Shelburne Museum, Shelburne, Vermont

The Town of Londonderry resides within the Connecticut River watershed, and a majority of developed land within the Town occurs along the West River. The Town has experienced major flooding events along the West River near Williams Dam.

In the Fall of 1927, Vermont experienced what is considered the worst flooding event recorded. That fall, the State was experiencing unusually high rainfall. Between November 2nd and November 4th, 1927, the State of Vermont recorded a rainfall depth of 8.71 inches. Flooding within Vermont rivers destroyed approximately 1,285 bridges, and killed 84 people. Notes associated with the following photo describe the pictured bridge, upstream of Williams Dam, to have been damaged or destroyed and replaced in 1928. The photo also shows that the store and mill from the 1908 photo remain.



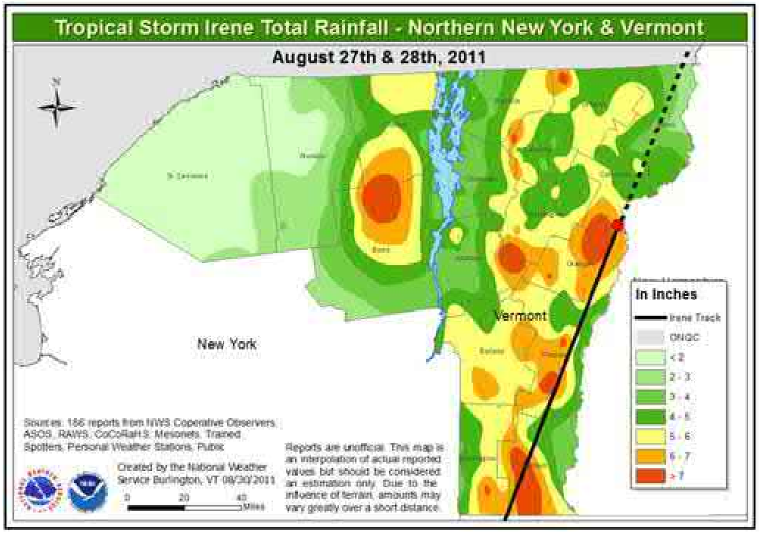
1928 – Bridge built after the flood of 1927, Bacon's store on right, Williams mill on other side of bridge.
Source: "Crossings, A History of Vermont Bridges" by Robert McCullough.

Documentation of flooding and other records of the dam between 1928 and the 1970's could not be found. However, in May and June 1973, Vermont again experienced above average rainfall. On June 28, 1973, a significant storm event with 7.19-inches of rainfall was recorded in South Londonderry. Notes associated with the following photo describe the bridge to be damaged again. In this photo, the mill structure appears to have been removed and there appears to be damage to the abutments of the dam. Vermont Dam safety reports that the last documented rehabilitation of the dam was in 1978 when the low-level gate structure was constructed and repairs were made to the primary spillway to address damages from the 1973 flood.

1973 – Intersection of Vt. Rte. 11 and 100 in north Londonderry village after 1973 flood
Source: Vermont State Archives and Record Administration

In June 2008, the Vermont Agency of Natural Resources issued Basin 11 Management Plan, West River, Williams River, Saxton River. This plan outlined known issues within the basin and effects to water quality, habitat, etc. The Plan discusses that Williams Dam be considered for dam removal due to deteriorating condition, blocking fish passage, sediment accumulations and potential safety hazards.

The second largest flooding event occurred in 2011, when Hurricane/Tropical Storm Irene passed through the Connecticut River watershed. NOAA reports that between 4 and 11-inches of rainfall occurred in Vermont on August 28, 2011. At Williams Dam in Londonderry, the West River overflowed the banks of the river and flooded the VT Rte 11 and 100 area.



2011 – Tropical Storm Irene Rainfall and Flooding in Londonderry on VT Route 100

Following the 2011 storm, discussion regarding flooding near Williams Dam resulted in structures adjacent the dam being removed to improve the floodplain in 2013. The 2016 Tactical Basin Plan for the West, Williams and Saxtons Rivers and adjacent Connecticut River Tributaries created a list of dams to be removed to have the greatest ecologic benefit, listing Williams Dam with the highest rank.

March 2022 - Ice from West River upstream of the Dam

Data Collection & Site Investigation

DuBois & King completed several site visits to collect information related to Williams Dam. This included a topographic and bathymetric survey of the dam, wetland review, a dam inspection, and sediment sampling.

Dam Survey

D&K conducted a limited survey of the Williams Dam and the surrounding area. The purpose of the survey was to collect key dam measurements and topographic/bathymetric information suitable for producing an existing conditions base plan and to develop conceptual alternative plans and construction cost estimates.

The survey took place on November 15 & 16, 2021. The survey was based upon the NAD83 VT feet State Plane horizontal datum and the NAVD88 feet vertical datum. The topographic survey included the dam and abutments, the VT Rte-11 bridge, ground shots along the upstream and downstream banks of the West River, and surrounding areas such as Edge Hill Road, the Veterans Park and existing dry hydrant location. In addition, a bathymetric survey was completed of a portion of the West River using a dual frequency sonar probe. The limits of the bathymetric survey extended 500-ft upstream of the dam and 100-ft downstream of the dam.

Survey data was imported to AutoCAD, a computer-aided engineering drafting software, to develop elevation models and site layout. This information was augmented with additional topographic information from a publicly available Light-Detection and Ranging (LiDAR) digital elevation model, Middle Connecticut River sub basin 2016 0.7-m DEM. An Existing Conditions Plan depicting Williams Dam and the surrounding area is included in **Appendix A**.

Wetland Review

D&K conducted a preliminary wetland investigation at the site. The purpose of the wetland investigation was to identify possible locations of wetland areas near the dam that may be impacted by modifications to the dam. This information is important to developing permitting requirements for each alternative.

Two wetlands were identified near the dam and approximate boundaries were established. This site visit occurred on November 30, 2021, outside of the growing season, and did not include formal wetland delineation. The wetlands are likely Class II because they are contiguous with the West River, but review by the district wetlands ecologist will be necessary to verify this wetland classification.

The Natural Resources Atlas Map shows no elements of concern (rare, threatened, or endangered species or significant natural communities) in the immediate project area. No significant natural communities were observed during the course of fieldwork. A field survey during the growing season would be necessary to determine whether rare, threatened, or endangered species are present in the project area. A memorandum summarizing the wetland investigation is included in **Appendix B**.

Dam Inspection

On November 30, 2021, D&K engineers including Charles Johnston P.E., Andrew Sampsell, and Bobby Lanzilotta, conducted a site visit to inspect the dam, take additional measurements of the dam, review the upstream and downstream areas of the West River, and meet with the Town to discuss the project.

The inspection began with a review of the primary spillway and low-level structure. The days leading up the inspection had a mix of rain and snow precipitation, which affected the conditions under which the inspection took place. The dam was observed to have approximately a foot of flow over the primary spillway and snow cover in the surrounding area. The primary spillway appears to be a stone masonry structure with a concrete cap. A concrete apron on the upstream side of the dam extends from the low-level structure on the right side of the river (directions looking downstream) to the left abutment. Pressurized leakage is occurring at different heights and locations on the downstream face of the structure.

November 2021 – Williams Dam

The low-level intake structure consists of a slide gate on the upstream face, a 6-foot corrugated metal outlet pipe, and open concrete flume on the downstream side. The condition of the overall structure is very poor. The slide gate stem is bent making the gate inoperable. The gate is sealed on the upstream side of the outlet pipe but there is some seepage at the bottom of the gate. The bottom of the gate seals to a wooden sill, and during the inspection the wood was observed to be cracks and covered in ice. Silt has accumulated on the upstream side of the gate, which may contribute to it being inoperable. Fine textured sediment is leaking through the gate sill and accumulating in the outlet pipe.

The outlet pipe is heavily deteriorated with rusting observed throughout the pipe. Soundings on the pipe indicated the metal pipe has delaminated from the concrete. Pressurized water leaks through the pipe and water flowing between the pipe and concrete at the outlet end of the pipe are further indicates that the pipe is delaminated from the concrete.

November 2021 – Low-Level Outlet

November 2021 – Dam to concrete structure

The concrete portion of the structure was observed to be in very poor condition. The section of the structure that the outlet pipe appears to have been constructed as a concrete cap over the stone masonry dam. Large portions of this concrete have spalled, exposing the stones and allowing hydraulic connection to the upstream pool. The concrete flume wall, which extends downstream of the dam, has separated from the base slab of the structure and water can be seen flowing between the wall and slab. The flume wall also has large spalls, however, no steel reinforcement was found in areas where the concrete has separated from the structure. The right flume wall was noted to be out-of-plumb, which may indicate a global stability failure of the wall.

November 2021 – Primary Spillway

November 2021 – Right wall of Outlet Flume

The right abutment consists of several components including the VT Rte-11 bridge abutment, the concrete wall upstream of the intake structure, the intake structure, and a riprap slope. During the inspection the ground was covered in snow, however, no seepage was noted in the earthen abutment area. This may indicate the concrete walls are acting as sufficient hydraulic cut-offs. The slope of the abutment is steep with a portion of the riprap extending into the river.

November 2021 – Left Abutment

November 2021 – Flow through left abutment

The left abutment is comprised of the banks of the West River that supports Edge Hill Road. The dam contact at the abutment is a combination of exposed bedrock and large riprap stone. The river at the time of the inspection was flowing through the riprap and along an exposed portion of bedrock along the far left side of the river. The left abutment appears to have been washed out during a high flood event, which allows the river flow around the concrete dam. The depth of the flow around the left side of the dam is difficult to determine due to a large portion being frozen at the time of the inspection.

The impounded area of the dam extends upstream of the VT Rte-11 bridge and through several bends of the West River. During the site visit, the majority of the impounded area was frozen with some exposed portions near the dam and along the edges of the river. The impoundment appears to be heavily filled with accumulated sediment. In one location, there appears to be a small island of sediment deposition near the right bank of the West River. A dry hydrant is located approximately 310-feet upstream of the dam.

Downstream of the dam, there is a scour hole at the toe of the dam, possibly from flow over the dam or from the natural formation of the bedrock the dam was constructed upon. Downstream, the inspection continued to observe crossings of the West River and Utley Brook, which converges with the West River approximately 1800-feet downstream of the dam. Other than the VT Rte-11 crossing at the dam, Rte-100 crosses the river twice downstream of the dam. Overall, the West River downstream of the dam consists of high banks with relatively flat surrounding floodplain.

Sediment Sampling

As part of the dam inspection, D&K collected two samples of sediment from the West River. The purpose of the sediment collection was to test the sediment for possible contaminant impacts. For future improvements, sediments removed during dredging activities may require testing for contaminants to verify if the sediment is acceptable to be disposed of as clean fill or development soils. River flow over the dam is disturbed and suspended sediments naturally collect upstream of the dam.

The first sample was collected on the left side of the west river under the VT Rte-11 Bridge. The second sample was collected from the edge of the river near the dry hydrant location. These sample location were selected due to the possible dredging that would be needed upstream of the dam for each of the evaluated alternatives, and potential dredging of the dry hydrant intake. The sample locations are shown on the Existing Conditions Plan in **Appendix A**.

Samples were sent to Endyne Inc. for testing. The samples were tested for:

- Total petroleum hydrocarbons in the gasoline and diesel range organics (EPA 8015 method),
- Oil & Grease (EPA 1664 method),
- Volatile and Semi-Volatile organic compounds (EPA 8260 & 8270 method),
- RCRA heavy metals (EPA 6020C/7471 method),
- Polychlorinated biphenyl (EPA 8082 method),
- Pesticides (EPA 8081B method), and
- Total Kjeldahl Nitrogen (TKN) (EPA 351.4 method)

The samples were tested and compared to the “Vermont Watershed Management Division’s Recommended Guidelines for Evaluating Contaminant Concentrations in Freshwater Sediments and the Potential for those Contaminants to Adversely Affect Aquatic Biota”. A summary of the results and comparison to Vermont standards are included in **Appendix C**.

The results of the sediment testing indicate that no contaminants were detected above the State of Vermont Threshold Effect Concentration (TEC) or Probable Effects Concentration (PEC) limits. Additional testing of material dredged from the West River will be required during construction; however, it was assumed the dredged sediment would be suitable for common fill in the alternative analysis.

Existing Conditions Hydraulic Analysis

To develop alternatives for Williams Dam, D&K conducted a hydraulic analysis of the dam. The purpose of this analysis was to model the dam during key design flood events (10-yr, 50-yr, 100-yr, and 1000-yr) and evaluate the dam’s performance in reference to the anticipated 2022 VT Dam Safety Program design requirements.

The hydraulic analysis was completed using US Army Corps of Engineers HEC-RAS (version 6.0) 2D hydraulic modeling software, which is a computer program that models the flow of water through two-dimensional terrain surfaces. The program is also used for analysis of peak water surface, velocities, flow, and mapping the extent of flooding.

The model was created utilizing the digital elevation model from the D&K survey and publically available LiDAR. The West River is part of the Federal Emergency Management Agency Flood Insurance Study (FEMA FIS) for Windham County, Vermont, which was completed to aid in the establishment of flood insurance rates. The FEMA studies model various aspects of watersheds and rivers to accurately establish extent of flooding for various storm events. FEMA FIS is widely accepted as an accurate measure of flooding. D&K utilized the study’s flow values for the hydraulic analysis of Williams Dam.

Flood Event	Flow (cubic feet per second (cfs))
10-year (10% probability)	5,419
50-year (2% probability)	11,500
100-year (1% probability)	11,759
500-year (0.2% probability)	20,552
1000-year (0.1% probability)	21,912

The existing conditions model began at a FEMA FIS cross-section approximately 4000-feet upstream of the dam. The model was extended 4100-feet downstream of the dam, beyond the confluence of Utley Brook and the West River. It was assumed that during larger storm events, Utley Brook, might cause backwater to Williams dam and have an impact upon flooding.

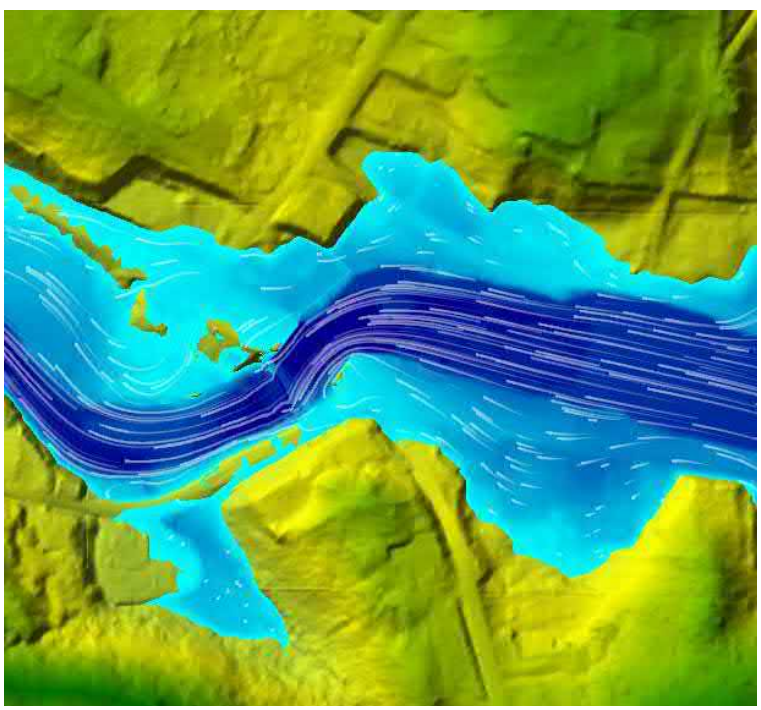
The model utilizes land cover aspects to determine flow along the terrain file. Land cover types such as open fields have different flow characteristics from wooded or urban areas. These land cover types were mapped utilizing ortho-imagery and notes from the site visit. In general, the Town of Londonderry was broken into three major land coverage complexes: agricultural, forest, and urban/residential.

The model also included features such as the VT Rte-11 bridge. The hydraulic opening of the bridge restricts the flow that reaches Williams Dam. Additional flow can reach the dam if flooding flows over or around the bridge. Due to this, the model includes information like the bridge deck, low chord steel beams, and concrete abutments.

Results from the model are separated into two important sections. The first section is taken at the upstream end of the bridge to capture information prior to the bridge restriction. The second section is taken at the dam.

Location	Associated Water Surface Elevation (ft.)				
	10-year	50-year	100-year	500-year	1000-year
Bridge (Deck El. 1151.7-ft)	1150.78	1154.14	1154.25	1156.88	1157.23
Dam (Spillway El. 1141.9-ft)	1145.08	1151.07	1151.25	1154.93	1155.33

Results from the model indicate that the bridge opening is restricting flow to the dam. Flow that diverts around the bridge flows through the surrounding area and re-enters the West River after to the dam. The model also shows the 10-year flood event is not expected to overtop the VT Rte-11 bridge. The flood inundation mapping associated with the existing dam for the 10-year and 100-year flood events are included in **Appendix D**.



HEC-RAS 2D Flow Analysis

Dam Safety Coordination

During the process of establishing the condition of Williams Dam, D&K coordinated with Vermont ANR Dam Safety Program (VT DSP). Meetings with the Town and VT DSP discussed the dam's condition, upcoming dam regulation changes, the dam's hazard classification, and other aspects of the dam.

Prior to D&K's involvement, VT DSP conducted an inspection of the Williams Dam on August 6, 2015. The inspection report identified concerns regarding the dam's condition and gives the dam an overall condition rating of Poor. Key observations from the 2015 inspection include:

- Numerous cracks within the concrete, forming spalls and voids and allowing leakage through the dam.
- Leakage through the wooden sill of the sluice gate at approximately 1,000 gallons per minute.
- The sluice gate stem is not operable due to a bend in the stem.
- Corrosion, leakage, and section loss in the 6-foot diameter outlet pipe.
- Cementitious material erosion is occurring within the construction joints in the right training wall.
- Leakage through the right abutment.

In the 2015 report, the State of Vermont classified Williams Dam as a Low Hazard Dam.

Dam hazard classifications are not based upon the current condition of the dam, but rather the potential impacts in the event of a dam failure. Dam classifications are defined as follows:

- Low Hazard – Dams where failure or mis-operation results in no probable loss of human life and low economic and environmental losses.
- Significant Hazard – Dams where failure or mis-operation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or other impacts of concern. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.
- High Hazard – Dams where failure or mis-operation will probably cause loss of human life.

As part of this study, D&K coordinated with the Vermont Dam Safety Program to complete an updated hazard classification of the dam. The classification of the dam is important to the alternative analysis as it establishes the regulatory and design standards for the dam rehabilitation and replacement alternatives.

Dams in the State of Vermont are regulated by 10 V.S.A Chapter 43, and the engineering guidelines associated with the existing law are considered outdated. The Dam Safety Program recently adopted new Administrative Rules, which went into effect on August 1, 2020. The administrative rules establish hazard classification updates, inspection schedules, and other requirements for dam owners. In addition to the Administrative Rules, Standard Engineering Rules are expected to be adopted in 2023, which will establish engineering design requirements for new and existing dams.

To quantify the potential impacts of a dam failure, a breach analysis of the dam through the downstream floodplain is typically completed. A breach analysis is helpful tool, not only for emergency action planning purposes, but can also support the selection of a project alternative (i.e. if the consequence of the dam failing is significant/costly this can support the decision to make capital expenditures to avoid these consequences). In discussions with Vermont Dam Safety the source for the Low Hazard classification was unknown and sediment accumulation may impact the classification due to downstream impacts.

A memorandum, dated March 2, 2022, by Vermont Dam Safety is included in **Appendix E**, which outlines a breach analysis and reclassification of Williams Dam to Significant Hazard. D&K provided information the Dam Safety Program from the Existing Conditions Hydraulic Analysis and estimates of water and sediment volume impounded by the dam. The Dam Safety program completed the breach analysis utilizing the DSS-Wise Lite program and analyzed Williams Dam under several scenarios:

- Sunny Dam Failure (260 cfs)
- Storm Day Failure (1,620 cfs)
- Storm Day Failure (11,500 cfs)

The reclassification of the dam was based on the potential impacts for property loss in the event of a dam failure.

Summary of Deficiencies

Williams Dam is in poor condition and requires action by the Town of Londonderry. The following is a list of deficiencies identified during the site inspection, by Vermont Dam Safety, and from the analysis.

1. Dam Structural Integrity

The dam structure is no longer acting as an efficient hydraulic cut-off and the integrity of the structure is questionable. Visual indicators, such as pressurized leakage, large cracking and spalling, and walls out-of-plumb show that the dam is experiencing significant deterioration. The dam does not appear to have been constructed with modern materials and is assumed to rely on the weight of the structure to resist loading. Structural stability of the dam was not analyzed for this study, however, the dam is likely experiencing unintended loading from sediment deposition.

Other aspects, such as erosion in the left abutment, has led to the West River to continue to erode through a low point. This area is susceptible to continued erosion of the earthen material, which may lead to a partial breach.

2. Inadequate Dam Operating Controls

   The Town lacks the ability to operate the low-level outlet stem to drain the impoundment in case of an emergency. The ability to reduce the water level behind the dam in a controlled way is crucial to increasing the stability of the dam in an emergency. Without the ability to lower the pond, a partial breach or full breach of the dam will result in an uncontrolled release.

   In addition, with no way to regularly exercise the low-level outlet to flush sediment downstream, sediment accumulation behind the dam has increased significantly. Dams naturally act as sediment traps, and regularly exercising the low-level outlet allows for movement of sediment downstream.

3. Insufficient Spillway Hydraulic Capacity

   Historical flooding near the dam structure has been documented. Hydraulic analysis by FEMA and D&K indicate that the combination of the VT Route 11 bridge and the dam restrict flow in the West River causing flooding upstream of the dam. Removal of the dam has been discussed in several ANR Basin Plans for the West River to reduce flooding and improve aquatic habitat.

Alternative Analysis

The Town of Londonderry requested the following scenarios to be analyzed:

- No Action
- Dam Rehabilitation
- Dam Replacement
- Dam Removal

D&K completed an analysis of these alternatives by outlining the key elements of each, preparing conceptual plans and opinion of construction costs, outlining permitting requirements and other dam safety concerns. Conceptual plans and overlay on ortho-imagery of each alternative are contained within **Appendix F** and estimated opinions of probable construction costs are in **Appendix G**. Each alternative is detailed below. The flood inundation mapping associated with the replacement and removal alternatives for the 10-year and 100-year flood events are included in **Appendix D**.

No Action Alternative

The focus of this alternative is to establish requirements and potential costs that the Town of Londonderry would encounter if one of the following alternatives were not implemented. In this case it was assumed the dam would remain in its current condition and that the Town would not implement any remedial measures to repair the dam.

Without improvements to the dam, the structure is expected to continue to deteriorate. The low-level structure flume walls are separating from the base of the structure, likely due to freeze and thaw of entrapped water between the wall and slab. In addition, the concrete cap of the stone dam is failing and exposing large portions of stone. The leakage through the stones may accelerate this process making the dam less stable. Failure of the dam may occur due to the deterioration of the dam. This alternative does not account for the costs associated with the potential downstream impacts of a failure or for reconstruction of the dam.

As outlined previously, the State of Vermont Dam Safety standards are in the process of being updated. These standards will continue to require the Dam Owner to continue to pay the annual dam registration fee, in addition to other expenses associated with future required inspections. The annual dam registration fee is $350 for Significant Hazard Dams.

Other expenses the Town may incur due to the new rule change include engineering fees associated with periodic and comprehensive dam inspection. The new administrative rule requires a Significant Hazard dam to have a periodic inspection every 5-years. The Dam Safety Program intends to complete the majority of these inspections, however, depending on their workload, VT DSP may require the Dam Owner to hire an engineer to complete the inspection. This inspection includes review of existing information, a site inspection, and producing an inspection report. To accommodate for this potential expense, the annual fee for this alternative and other alternatives that maintain the dam, includes a set aside of $500/year.

In addition to the periodic inspection, the Dam Safety program also requires a comprehensive inspection of Significant Hazard dams every 15-years. This is a more detailed inspection to be completed by an engineer hired by the Dam Owner. It involves a review and update to all studies and analyses (H&H, stability, breach, etc.), and an in-depth inspection of the dam. The requirements for this are not yet established, however, to accommodate this future expense the annual fee for this alternative and other alternatives that maintain the dam, includes a set aside of $1,150/year.

Lastly, with the implementation of the new standards, the State of Vermont will focus initially on High and Significant Hazard Dams to ensure that action is taken to rehabilitate dams in poor condition. Due to the current condition of the dam and the reclassification to Significant

Hazard, a no action alternative may not be acceptable to the Dam Safety Program. Future inspections by the State will include similar recommendations as the 2015 inspection report, which was to prepare plans for repair, replacement, or removal of the dam. In the event the Town does not complete the required recommendations, the Dam Safety program may take enforcement actions to ensure public safety. The cost of completing future recommendations and the cost of future enforcement actions are not included in this alternative.

Dam Rehabilitation Alternative

This alternative retains the existing dam and maintains the current water level. The existing spillway is left in place with minor repairs. This alternative requires that a new concrete wall to be constructed on the upstream face of the dam. This wall will be designed to be structurally independent of the existing dam. The following is a list of improvements associated with this alternative:

- Construct new concrete spillway at the upstream face of the existing spillway.
- Dredge sediment for approximately 25-feet upstream of existing dam. This should allow for the construction of the new upstream concrete wall, and removes sediment load from the structure.
- Demolish a portion of the existing low-level outlet structure to remove the headwall, corrugated outlet pipe, and slide gate.
- Extend the new upstream wall across the existing outlet structure and construct a new headwall with access deck, new slide gate, and downstream concrete flume walls within existing walls.
- Construct new trashrack/debris diversion to protect slide gate and access deck.
- Install new abutment training walls and stone riprap along abutments to reduce erosion of river banks during large flood events.
- Dredge existing dry hydrant location.

This alternative is estimated to have a probable construction cost of $800,000. This involves the new cast-in-place upstream wall, sediment dredging, channel restoration, and other construction related items. It was assumed that sediment dredged from the river would be retained and disposed of by the Contractor.

Beyond construction costs, there will be additional costs such as engineering and permitting fees. Engineering for this project will involve a preliminary design, coordination with various permitting agencies, permitting of the project, and final design. Other services such as bidding and construction administration and observation could be included. It is estimated an additional $80,000 will be needed to advance this alternative from a conceptual alternative to a complete construction package.

The following are anticipated permits and coordination required to be able to construct this alternative:

- Dam Alteration Order,
- Wetlands Permit,
- Stream Alteration & Crossings Permit,
- Army Corps of Engineers Section 404 Wetland Permit,
- Federal Permit for work in Rivers and Streams,
- Work in the State Right of Way Permit,
- Coordination with Vermont Division of Historic Preservation, and
- Coordination with Vermont Fish & Wildlife.

There may be other coordination items or permits required with specific construction techniques such as discharging of water from construction activities downstream. The permit application fees for the project vary depending upon areas of impact. The estimated area of impacts for this alternative is approximately 2,250 sq. feet. It is estimated the permitting fees for the project are approximately $10,000. Information sheets discussing the permits are included in **Appendix H**.

Additional analysis was completed to detail a secondary rehabilitation alternative. This alternative utilized a roller compacted spillway on the downstream face of the dam to provide stability and hydraulic cut-off. An exhibit of this secondary rehabilitation alternative in included in **Appendix F**. This alternative is estimated to have a probable construction cost of $675,000. This involves the new roller compacted concrete spillway, sediment dredging, channel restoration, and other construction related items. It was assumed that permitting fees and engineering fees associated with this alternative are similar to the upstream concrete wall alternative.

Dam Replacement Alternative

This alternative involves constructing a new concrete dam downstream of the existing dam. The location of the new dam, approximately 20-ft downstream was selected to allow for a longer spillway to improve hydraulics and to allow for construction of the new dam with the existing dam in-place. The following is a list of improvements associated with this alternative:

- Construct new concrete dam downstream of the existing dam. This will include a new spillway section, and new low-level outlet section. The new dam will be maintain a similar normal pool and will be approximately 10-ft longer between the left abutment and outlet structure.

- New low-level outlet section will have similar improvements as the previous alternative. New slide gate, new trashrack/debris diversion, new access deck, and new outlet flume.
- Dredge sediment approximately 25-feet upstream of existing dam. Dredging is to allow for the demolition of existing dam.
- Demolish the existing dam. To preserve its historic significance, construct a public information board in Veterans' Park.
- Install new abutment training walls and stone riprap along abutments to reduce erosion of river banks during large flood events. Training wall would tie into the existing dam abutments to provide hardened stream edge to contain flow over the dam.
- Abandon existing hydrant location and install new hydrant location at the Veteran's Park. The intake/strainer will be positioned within the trashrack/sediment diversion to protect components.

This alternative is estimated to have a probable construction cost of $1,186,000. This involves the construction of the new dam, demolition of the existing dam, sediment dredging, new dry hydrant, upstream and downstream channel restoration, and other construction related items. It was assumed that sediment dredged from the river would be retained and disposed of by the Contractor.

Similar to the previous alternative, this alternative will involve various engineering tasks and permitting assistance. It is estimated that $120,000 will be needed to progress this alternative from a conceptual alternative to a complete construction package. This engineering fee is expected to be larger than the rehabilitation alternative due to both the increase in design requirements and permitting requirements compared to the rehabilitation alternative.

The following are anticipate permits and coordination required to be able to construct this alternative:

- Dam Alteration Order,
- Wetlands Permit,
- Stream Alteration & Crossings Permit,
- Army Corps of Engineers Section 404 Wetland Permit,
- Federal Permit for work in Rivers and Streams,
- Work in the State Right of Way Permit,
- Coordination with Vermont Division of Historic Preservation, and
- Coordination with Vermont Fish & Wildlife.

Similar to the previous alternative, additional permits and coordination that may be needed. The estimated area of impacts for this alternative is approximately 13,250 sq. feet. Due to increased impacts to wetlands and stream alterations, the estimated the permitting fees for the project are $23,000.

Dam Removal Alternative

This alternative involves dredging the West River and demolishing the existing dam. Based on the historic information and the downstream river bottom, it is presumed that there is a bedrock bottom of the West River below the sediment. The goal will be to remove the sediment to the natural bottom to create a stable channel. The following is a list of improvements associated with this alternative:

- Dredge upstream of the existing dam to the natural channel bottom or create a sloped stable channel using natural stabilization techniques and stone rip-rap.
- Demolish the existing dam. To preserve its historic significance, construct a public information board in Veterans' Park.
- Abandon existing hydrant location.

This alternative is estimated to have a probable construction cost of $364,000. This involves demolition of the existing dam, sediment dredging, removal of the existing dry hydrant, upstream and downstream channel restoration, and other construction related items. It was assumed that sediment dredged from the river would be retained and disposed of by the Contractor.

Similar to the previous alternatives, this alternative will involve various engineering tasks and permitting assistance. The majority of the work will be involved with coordination with permitting agencies on the channel restoration. It is estimated that $40,000 will be needed to progress this alternative from a conceptual alternative to a complete construction package.

The following are anticipate permits and coordination required to be able to construct this alternative:

- Dam Alteration Order,
- Wetlands Permit,
- Stream Alteration & Crossings Permit,
- Army Corps of Engineers Section 404 Wetland Permit,
- Federal Permit for work in Rivers and Streams,
- Work in the State Right of Way Permit,
- Coordination with Vermont Division of Historic Preservation, and
- Coordination with Vermont Fish & Wildlife.

Similar to the previous alternative, additional permits and coordination that may be needed. The estimated area of impacts for this alternative is approximately 21,750 sq. feet. Due to impacts to wetlands and stream alterations, the estimated the permitting fees for the project are approximately $21,000.

Summary of Alternative Costs & Possible Funding Sources

The estimated probable construction costs included a 30% contingency due to some gaps in information for each alternative. These include:

- Unknown soil conditions and depth of bedrock,
- Unconfirmed State of Vermont dam design standards, and
- Lack of records/plans depicting the original construction of the dam.

The following table outlines the total costs for each alternative:

Owner Costs	No-Action	Dam Rehabilitation A	Dam Rehabilitation B	Dam Replacement	Dam Removal
Annual Fees	$2,000	$2,000	$2,000	$2,000	-
Construction Cost	$0	$808,000	$675,000	$1,186,000	$364,000
Engineering Fees	$0	$80,000	$80,000	$120,000	$40,000
Permit Application Fees	$0	$10,000	$10,000	$23,000	$21,000
Total	$2,000	$900,000	$767,000	$1,331,000	$425,000

The funding for the selected alternative is anticipated to be by the Town of Londonderry; however, there are outside funding sources available. During the coordination meetings with the Dam Safety program, several funding sources we discussed.

The dam replacement alternative currently has no potential outside funding source. The Dam Safety program discussed a possible High Hazard Potential Dam Grant program through FEMA. This program is only for High Hazard dams but it may be expanded in the future.

The dam rehabilitation alternative could receive funding through the Vermont State Historic Preservation Grants. This program has funded dam rehabilitations in the past. To qualify for this grant, Williams Dam would need to be listed or determined eligible for listing in the National Register of Historic Places. This funding would likely not be available for the rehabilitation alternative that would cap the downstream side of the existing dam.

The dam removal alternative has a much larger source for potential outside funding. The Vermont Agency of Natural Resources maintains a list of dam removal funding sources, including Federal funding by NOAA, the US Fish and Wildlife services, and State grants. Successful examples of dam removal utilizing outside funding sources include the Magic Mountain Dam removal in Londonderry, which received fundraising and grant writing assistance from CRC. Funding for this alternative can contribute to the engineering design, permitting, and construction costs.

See **Appendix I** for a list of potential funding sources for the Alternatives.

Summary & Conclusions

	Dam Alternatives			
	No-Action	**Dam Rehabilitation (both)**	**Dam Replacement**	**Dam Removal**
Addresses Deficiencies	This alternative does not address any deficiencies.	✓✓ This alternative improves structural integrity, and dam controls	✓✓✓ This alternative replaces existing dam with dam design to all applicable standards.	✓✓✓ This alternative removes the existing dam.
Continued Maintenance Costs and Annual Fees		✓✓ Improves structural integrity and dam controls	✓✓✓ Replaces existing dam with dam design to all applicable standards.	✓✓✓ This alternative removes the existing dam.
Total Cost	$2,000 Least expensive alternative, however requires future action which will result in additional costs.	✓✓ $767,000/$900.000	✓ $1,331,000	✓✓✓ $425,000 Most cost effective, removes dam related future expenses.
Additional Funding Available		✓ Possible funding through State Historic Preservation Grant		✓✓✓ Numerous funding options.

The following is a summary of the report findings and conclusions of analysis:

1. Williams Dam is in poor condition and requires action by the Owner to address deficiencies that may lead to a dam breach. Future anticipated (2023) dam safety standards would require the Owner to complete some remedial action to the dam.
2. The dam structure is no longer acting as an efficient hydraulic cut-off and the integrity of the structure is questionable. Visual indicators, such as pressurized leakage, large cracking and spalling, and walls out-of-plumb, show that the dam is experiencing significant deterioration.
3. The Town lacks the ability to drain the impoundment in case of an emergency due to damage to the low-level outlet stem. The ability to reduce the water level behind the dam in a controlled way is crucial to increasing the stability of the dam in an emergency. Without the ability to lower the pond, a partial breach or full breach of the dam will result in an uncontrolled release.
4. Hydraulic analysis by FEMA and D&K indicate that the combination of the VT Route 11 bridge and the dam restrict flow in the West River causing flooding upstream of the dam.
5. The No-Action Alternative is not recommended due to the condition of the dam. The Owner will likely be required by the State of Vermont to correct deficiencies in the near future.
6. The least costly alternative is Dam Removal. This alternative also addresses the existing dam deficiencies by removing the structure and hazard potential. There are no future dam fees and maintenance costs associated with the alternative. This alternative has several outside funding sources.
7. The Dam Rehabilitation alternative is the most cost effective alternative that maintains the dam. This alternative provides the structural integrity by being independent of the existing dam, and replaces inoperable controls at the dam. This alternative may have a potential outside funding source.
8. The Dam Replacement alternative addresses all the existing deficiencies and the new dam will be designed to current applicable standards. It is the most expensive option and may have most permitting requirements.

After the Town selects a preferred alternative, the next steps will be to coordinate with the State of Vermont Dam Safety program on the Town's intention for Williams Dam and to secure possible funding sources. Following those actions, the project would progress to preliminary design, permitting, final design, and construction of the project. Based upon the date of the upcoming Town Meeting day on April 30, 2022, and the time needed to design, permit, and bid the project, the construction of the project may not occur until the 2024 construction season.

Appendices

Appendix A – Existing Conditions Plan

Appendix B – Wetlands Memorandum

Appendix C – Sediment Testing and Comparison

Appendix D – Hydraulic Analysis Mapping

Appendix E – Vermont Dam Safety Hazard Classification

Appendix F – Alternative Plans

Appendix G – Alternative Opinion of Probable Construction Costs

Appendix H – Alternative Permitting

Appendix I – Potential Funding Sources

References

1. History. Londonderry Arts and Historical Society, www.lahsvt.org/history.
2. Child, Hamilton, b. 1836. Gazetteer And Business Directory of Windham County, Vt., 1724-1884. Syracuse, N.Y.: Printed at the Journal office, 1884.
3. US Department of Commerce, NOAA. "Flooding in Vermont." National Weather Service, NOAA's National Weather Service, 19 Apr. 2018, www.weather.gov/safety/flood-states-vt.
4. Vermont Watershed Management Division's Recommended Guidelines for Evaluating Contaminant Concentrations in Freshwater Sediments and the Potential for those Contaminants to Adversely Affect Aquatic Biota
5. Federal Emergency Management Agency Flood Insurance Study (FEMA FIS) for Windham County, Vermont. September 28, 2007
6. Vermont Environmental Protection Rules, Vermont Dam Safety Rules, August 1, 2020.
7. State Of Vermont, Agency of Commerce and Community Development, https://accd.vermont.gov/historic-preservation/funding/historic-preservation-grants

Appendix A

Existing Conditions Plan

WILLIAMS DAM STUDY EXISTING CONDITIONS

SCALE 1" : 20'

20 0 10 20 40 80

SCALE IN FEET

DATUM:

VERTICAL:	NAVD 88 GPS DERIVED
HORIZONTAL:	NAD 83 GPS DERIVED

DuBois & King inc.

6 GREEN TREE DR.
S. BURLINGTON, VT 05401
TEL: (802) 728-3376
FAX: (866) 783-7101
www.dubois-king.com

PROFESSIONAL SEAL

NOT FOR CONSTRUCTION

NO.	DATE	DESCRIPTION	BY	CK'D

TOWN OF LONDONDERRY
100 OLD SCHOOL STREET
S. LONDONDERRY, VT 05155

WILLIAMS DAM STUDY (#115.01)

LONDONDERRY, VT

SHEET TITLE

EXISTING CONDITIONS SITE PLAN

DRAWN BY	DATE
RJL	PROGRESS
CHECKED BY	D&K PROJECT #
	827442
PROJ. ENG.	
CWJ	

SHEET NUMBER

1

Appendix B

Wetland Memorandum

MEMORANDUM

To: Charles Johnston, Project File
Date: December 2, 2021
From: Grace Glynn
Subject: Londonderry Williams Dam Wetlands Review
Project No.: 827442

This memorandum summarizes the preliminary wetlands investigation performed on November 30, 2021 at the Williams Dam at 2306 N Main St in Londonderry, VT, as shown on the attached Natural Resource Atlas Map.

Two wetlands were identified in the vicinity of the dam. This site visit occurred outside of the growing season and did not include formal wetland delineation, but the approximate wetland boundaries are shown on the attached map, and photos of the wetland are attached. Downstream of the dam, the river banks are generally steep and dominated by Japanese knotweed, a noxious invasive species.

Both wetlands are palustrine emergent/scrub-shrub (PEM/SS) and are located along the edge of the West River, upstream from the dam. The wetlands appear to be dominated by purple loosestrife, soft rush, cattails, meadowsweet, water horehound, and reed canary grass. The wetlands principal functions and values likely include wildlife habitat and flood storage. The wetlands are likely Class II because they are contiguous with the West River, but review by the district wetlands ecologist would be necessary to verify this wetland classification.

Work in any wetland or below Ordinary High Water elevations within the West River would require an Army Corps of Engineers Section 404 Wetlands Permit. Work in any Class II wetland or in the 50ft jurisdictional buffer of any Class II wetland would require a VT Wetlands Permit. Because the wetlands above the dam are Surface Water Margins located along waters of the state, wetland and buffer zone impacts over 150 square feet would likely require an Individual Wetland permit from the VT Wetlands Program. In general, Individual Wetland permits can take from 3-6 months and authorizations under the Wetland General permit can take from 1-3 months to process from the receipt of complete application to issuance of permit decision.

In order to determine potential wetland impacts and permitting needs, wetlands should be formally delineated during the growing season in accordance with the COE 1987 Wetland Delineation Manual and the COE 2012 Regional Supplement for the Northcentral and Northeast Region.

Work within the mapped River Corridor of the West River may be subject to municipal regulation in order to comply with Vermont's Flood Hazard and River Corridor Rule. Work involving movement of over 10 CY of material within the riverbed may require a Stream Alteration permit through the VT Department of Environmental Conservation's River Management Program.

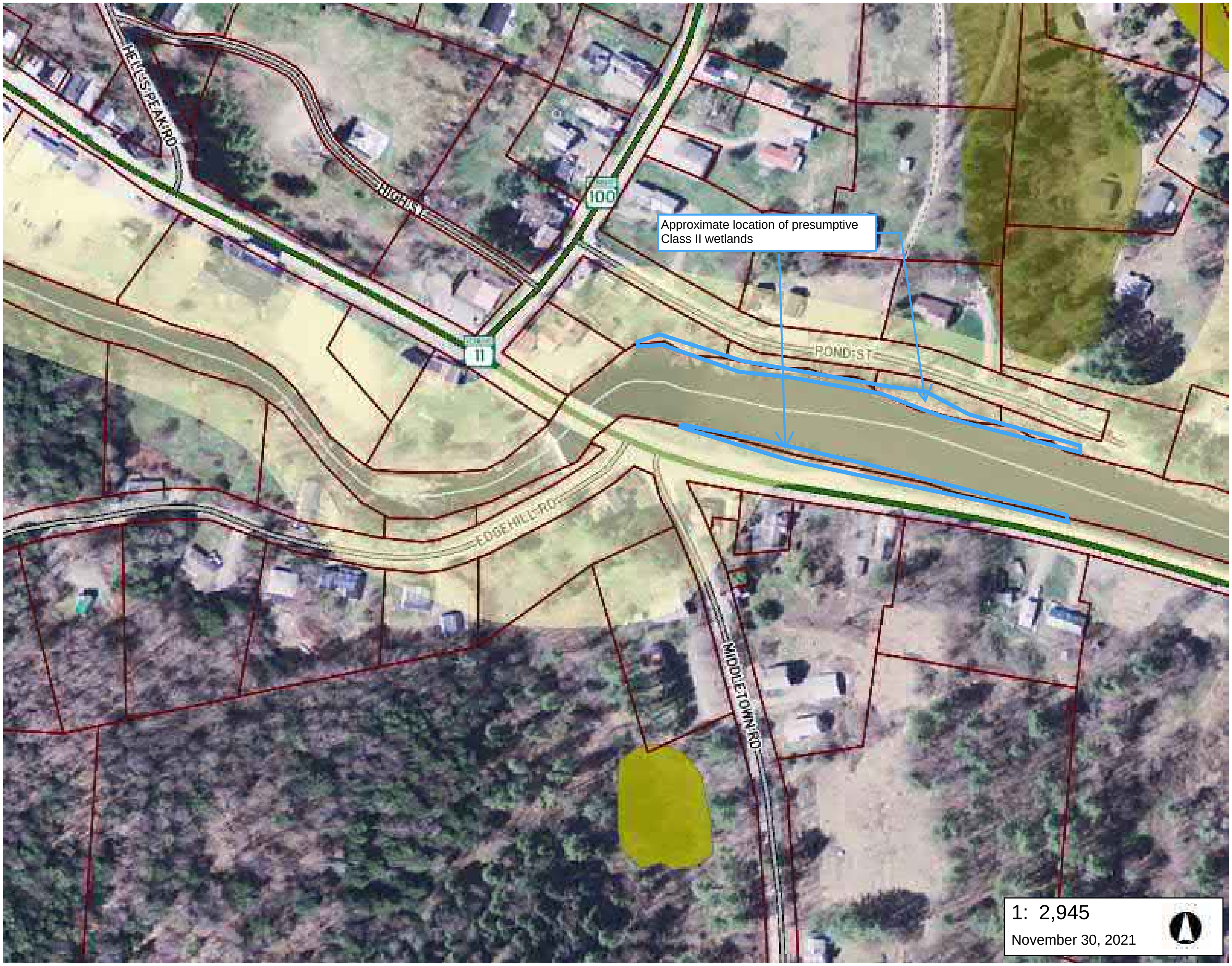
The Natural Resources Atlas Map of the area shows no elements of concern (rare, threatened, or endangered species or significant natural communities) in the immediate project area, as shown on the attached Natural Resources Map. No significant natural communities were observed during the course of field work. A field survey during the growing season would be necessary to determine whether rare, threatened, or endangered species are present in the project area.

Londonderry Wetlands Map

Vermont Agency of Natural Resources

VERMONT

vermont.gov



1: 2,945

November 30, 2021

150.0 0 75.00 150.0 Meters

WGS_1984_Web_Mercator_Auxiliary_Sphere

1" = 245 Ft. 1cm = 29 Meters

THIS MAP IS NOT TO BE USED FOR NAVIGATION

LEGEND

Wetland - VSWI
- Class 1 Wetland
- Class 2 Wetland
- Buffer

Wetlands Advisory Layer

River Corridors (Aug 27, 2019)
- .5 - 2 sqmi.
- .25-.5 sqmi.

Soils - Hydric

Parcels (standardized)

Roads
- Interstate
- US Highway; 1
- State Highway
- Town Highway (Class 1)
- Town Highway (Class 2,3)
- Town Highway (Class 4)
- State Forest Trail
- National Forest Trail
- Legal Trail
- Private Road/Driveway
- Proposed Roads

Stream/River
- Stream
- Intermittent Stream

Town Boundary

NOTES

Map created using ANR's Natural Resources Atlas

Williams Dam, Londonderry VT Wetlands Review
November 30, 2021

Surface margin wetland along the West River, looking west toward the dam

Downstream side of the dam, looking south from N Main St.

Appendix C

Sediment Testing and ANR Sediment Quality Guidelines

Town of Londonderry
William's Dam Alternative Study
Upstream Sediment Sampling

	ANR		Sampling Locations	
Substance	*TEC*	**PEC**	Bridge Abutment	Dry Hydrant
Metals (in mg/kg - ppm DW)				
Arsenic	*9.79*	**33.0**	ND < 3.6	ND < 7.5
Cadmium	*0.99*	**4.98**	ND < 0.36	ND < 0.75
Chromium	*43.4*	**111.0**	7.3	9.7
Copper	*31.6*	**149.0**	-	-
Lead	*35.8*	**128.0**	7.4	ND < 15.0
Mercury	*0.18*	**1.1**	ND < 0.051	ND < 0.093
Nickel	*22.7*	**48.6**	-	-
Zinc	*121.0*	**459.0**	-	-
Polycyclic Aromatic Hydrocarbons (in µg/kg - ppm DW)				
Anthracene	*57.2*	**845.0**	ND < 24.1	ND < 31.8
Benz(a)anthracene	*108.0*	**1050.0**	ND < 24.1	ND < 31.8
Benzo(a)pyrene	*150.0*	**1450.0**	ND < 12.0	ND < 15.9
Chrysene	*166.0*	**1290.0**	ND < 24.1	ND < 31.8
Dibenzo(a,h)anthracene	*33.0*		ND < 12.0	ND < 15.9
Fluoranthene	*423.0*	**2230.0**	ND < 24.1	ND < 31.8
Fluorene	*77.4*	**536.0**	ND < 24.1	ND < 31.8
Naphthalene	*176.0*	**561.0**	ND < 24.1	ND < 31.8
Phenanthrene	*204.0*	**1170.0**	ND < 24.1	ND < 31.8
Pyrene	*195.0*	**1520.0**	ND < 24.1	ND < 31.8
Total PAHs	*1610.0*	**22800.0**	204.8	270.3
Polychlorinated Biphenyls (in µg/kg - ppm DW)				
Total PCBs	*59.8*	**676**		
Organochlorine Pesticides (in µg/kg - ppm DW)				
Chlordane	*3.24*	**17.6**	ND < 25.0	ND < 31.9
Dieldrin	*1.9*	**61.8**	ND < 5.0	ND < 6.4
Sum DDD	*4.88*	**28.0**	ND < 5.0	ND < 6.4
Sum DDE	*3.16*	**31.3**	ND < 5.0	ND < 6.4
Sum DDT	*4.16*	**62.9**	ND < 5.0	ND < 6.4
Total DDTs	*5.28*	**572.0**		
Endrin	*2.22*	**207.0**	ND < 5.0	ND < 6.4
Heptachlor Epoxide	*2.47*	**16.0**	ND < 5.0	ND < 6.4
Lindane (gamma-BHC)	*2.37*	**4.99**	ND < 5.0	ND < 6.4

1. ANR Limits from Vermont Watershed Management Division's Recommended Guidelines for Evaluating Contaminant Concentrations in Freshwater Sediments and Potential for those Contaminants to Adversely Affect Aquatic Biota
2. TEC = Threshold Effect Concentration; PEC = Probable Effects Concentration
3. "ND < " result was below the detectable threshold for the test.

ENDYNE Inc.
Environmental Laboratories

Dubois & King, Inc.		PROJECT:	Williams Dam
6 Green tree Drive	080439	WORK ORDER:	**2112-35270**
So. Burlington, VT 05403		DATE RECEIVED:	December 01, 2021
		DATE REPORTED:	December 17, 2021
Atten: Charlie Johnston		SAMPLER:	CWJ

Laboratory Report

Enclosed please find the results of the analyses performed for the samples referenced on the attached chain of custody. All required method quality control elements including instrument calibration were performed in accordance with method requirements and determined to be acceptable unless otherwise noted.

The column labeled Lab/Tech in the accompanying report denotes the laboratory facility where the testing was performed and the technician who conducted the assay. A "W" designates the Williston, VT lab under NELAC certification ELAP 11263; "R" designates the Lebanon, NH facility under certification NH 2037 and “N” the Plattsburgh, NY lab under certification ELAP 11892. “Sub” indicates the testing was performed by a subcontracted laboratory. The accreditation status of the subcontracted lab is referenced in the corres ponding NELAC and Qual fields. The Williston, VT fac ility is also ISO/IEC 17025:2017 accredited for Total Coliform and E coli by SM9223B.

The NELAC column also denotes the accredit ation status of each laboratory for each reported parameter. “A” indicates the referenced laboratory is NELAC accredited for the parameter reported. “N” indicates the laboratory is not accredited. “U” indicates that NELAC does not offer accreditation fo r that parameter in that specific matrix. Test results denoted with an “A” meet all National Environmental Laboratory Accreditation Program requirements except where denoted by pertinent data qualifiers. Test results are representative of the samples as t hey were received at the laboratory

Endyne, Inc. warrants, to the best of its knowledge and belief, the accuracy of the analytical test results contained in this report, but makes no other warranty, expressed or implied, especially no warranties of mercha ntability or fitness for a particular purpose.

Reviewed by:

Harry B. Locker, Ph.D.
Laboratory Director

Laboratory Report DATE REPORTED: 12/17/2021

CLIENT: Dubois & King, Inc. WORK ORDER: **2112-35270**
PROJECT: Williams Dam DATE RECEIVED: 12/01/2021

001 Site: Bridge Location Date Sampled: 11/30/21 Time: 11:30

Parameter	Result	Units	Method	Analysis Date/Time	Lab/Tech	NELAC	Qual.
TKN	1,100	mg/Kg, dry	EPA 351.2	12/8/21	N MAP	U	
Phosphorus, Total	440	mg/Kg, dry	EPA 6010C	12/3/21	W FAA	U	
Mercury Digestion	Digested		EPA 7471B	12/8/21	W FAA	A	
Metals Solids Digestion	Digested		EPA 3050B	12/2/21	W FAA	A	
Arsenic, Total	< 3.6	mg/Kg, dry	EPA 6010C	12/3/21	W FAA	A	
Barium, Total	42	mg/Kg, dry	EPA 6010C	12/3/21	W FAA	A	
Cadmium, Total	< 0.36	mg/Kg, dry	EPA 6010C	12/3/21	W FAA	A	
Chromium, Total	7.3	mg/Kg, dry	EPA 6010C	12/3/21	W FAA	A	
Lead, Total	7.4	mg/Kg, dry	EPA 6010C	12/3/21	W FAA	A	
Mercury, Total	< 0.051	mg/Kg, dry	EPA 7471B	12/9/21	W FAA	A	
Selenium, Total	< 7.2	mg/Kg, dry	EPA 6010C	12/3/21	W FAA	A	
Silver, Total	< 3.6	mg/Kg, dry	EPA 6010C	12/3/21	W FAA	A	
Oil & Grease	255	mg/Kg, Dry	modified EPA 1664A	12/14/21	W CLD	N	
Volatile Organic Compounds							
Prep EPA 5035A	Complete		EPA 5035A-H	12/1/21	W TRP	A	
Dichlorodifluoromethane	< 715	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
Chloromethane	< 715	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
Vinyl chloride	< 286	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
Bromomethane	< 715	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
Chloroethane	< 715	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
Trichlorofluoromethane	< 286	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
Diethyl ether	< 715	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
1,1-Dichloroethene	< 143	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
Acetone	< 1,430	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
Carbon disulfide	< 715	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
Methylene chloride	< 1,430	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
t-Butanol	< 3,580	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
Methyl-t-butyl ether (MTBE)	< 286	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
trans-1,2-Dichloroethene	< 143	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
Di-isopropyl ether (DIPE)	< 286	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	U	
1,1-Dichloroethane	< 143	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
Ethyl-t-butyl ether (ETBE)	< 286	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	U	
2-Butanone	< 2,860	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
2,2-Dichloropropane	< 143	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
cis-1,2-Dichloroethene	< 143	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
Bromochloromethane	< 286	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
Chloroform	< 143	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
Tetrahydrofuran	< 1,430	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	U	
1,1,1-Trichloroethane	< 143	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
Carbon tetrachloride	< 143	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
1,1-Dichloropropene	< 143	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
Benzene	< 143	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
t-Amylmethyl ether (TAME)	< 286	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	U	
1,2-Dichloroethane	< 143	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
Trichloroethene	< 143	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
1,2-Dichloropropane	< 286	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	

Laboratory Report DATE REPORTED: 12/17/2021

CLIENT: Dubois & King, Inc. WORK ORDER: **2112-35270**
PROJECT: Williams Dam DATE RECEIVED: 12/01/2021

001 Site: Bridge Location Date Sampled: 11/30/21 Time: 11:30

Parameter	Result	Units	Method	Analysis Date/Time	Lab/Tech	NELAC	Qual.
Dibromomethane	< 286	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
Bromodichloromethane	< 143	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
cis-1,3-Dichloropropene	< 143	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
4-Methyl-2-pentanone (MIBK)	< 1,430	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
Toluene	< 143	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
trans-1,3-Dichloropropene	< 143	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
1,1,2-Trichloroethane	< 143	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
Tetrachloroethene	< 143	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
1,3-Dichloropropane	< 143	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
2-Hexanone	< 1,430	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
Dibromochloromethane	< 143	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
1,2-Dibromoethane	< 286	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
Chlorobenzene	< 143	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
Ethylbenzene	< 143	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
1,1,1,2-Tetrachloroethane	< 286	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
Xylenes, Total	< 286	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
Styrene	< 143	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
Bromoform	< 286	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
Isopropylbenzene	< 143	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
1,1,2,2-Tetrachloroethane	< 286	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
Bromobenzene	< 143	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
n-Propylbenzene	< 286	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
1,2,3-Trichloropropane	< 286	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
2-Chlorotoluene	< 286	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
1,3,5-Trimethylbenzene	< 286	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
4-Chlorotoluene	< 286	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
t-Butylbenzene	< 286	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
1,2,4-Trimethylbenzene	< 286	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
s-Butylbenzene	< 286	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
4-Isopropyltoluene	< 286	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
1,3-Dichlorobenzene	< 286	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
1,4-Dichlorobenzene	< 286	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
1,2,3-Trimethylbenzene	< 286	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
n-Butylbenzene	< 286	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
1,2-Dichlorobenzene	< 286	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
1,2-Dibromo-3-Chloropropane	< 286	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
1,2,4-Trichlorobenzene	< 286	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
1,3,5-Trichlorobenzene	< 286	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
Hexachlorobutadiene	< 286	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
Naphthalene	< 286	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
1,2,3-Trichlorobenzene	< 286	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
Surr. 1 (Dibromofluoromethane)	108	%	EPA 8260C	12/1/21	W TRP	U	
Surr. 2 (Toluene d8)	102	%	EPA 8260C	12/1/21	W TRP	U	
Surr. 3 (4-Bromofluorobenzene)	99	%	EPA 8260C	12/1/21	W TRP	U	
Unidentified Peaks	0		EPA 8260C	12/1/21	W TRP	U	
TPH-GRO Package							

Laboratory Report DATE REPORTED: 12/17/2021

CLIENT: Dubois & King, Inc. WORK ORDER: **2112-35270**
PROJECT: Williams Dam DATE RECEIVED: 12/01/2021

001 Site: Bridge Location Date Sampled: 11/30/21 Time: 11:30

Parameter	Result	Units	Method	Analysis Date/Time	Lab/Tech	NELAC	Qual.
Prep EPA 5035A High Level	Complete		EPA 5035A-H	12/2/21	W TRP	N	
C5-C10 TPH GRO	< 11.4	mg/Kg, dry	EPA 8260C	12/2/21	W TRP	N	
> C10 Volatile Hydrocarbons	< 11.4	mg/Kg, dry	EPA 8260C	12/2/21	W TRP	U	
TPH DRO Package							
Extraction	Completed		EPA 3550C	12/10/21	W EM	A	
C7-C10 TPH	< 28.6	mg/Kg, dry	EPA 8015D	12/13/21	W DPD	U	
C10-C28 TPH-DRO	69.8	mg/Kg, dry	EPA 8015D	12/13/21	W DPD	A	
C28-C40 TPH	22.5	mg/Kg, dry	EPA 8015D	12/13/21	W DPD	U	
Tot. Petroleum Hydrocarbons	92.3	mg/Kg, dry	EPA 8015D	12/13/21	W DPD	U	
Hydrocarbon Window	C14-C34		EPA 8015D	12/13/21	W DPD	U	
Priority Pollutant Pesticides							
Extraction	Completed		EPA 3545A	12/13/21	W CLD	A	
alpha-BHC	< 5.0	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	
gamma-BHC (Lindane)	< 5.0	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	
beta-BHC	< 5.0	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	
delta-BHC	< 5.0	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	
Heptachlor	< 5.0	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	
Aldrin	< 5.0	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	
Heptachlor Epoxide	< 5.0	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	
4,4'-DDE	< 5.0	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	
Endosulfan I	< 5.0	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	
Dieldrin	< 5.0	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	
Endrin	< 5.0	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	
4,4'-DDD	< 5.0	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	
Endosulfan II	< 5.0	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	
4,4'-DDT	< 5.0	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	AN1
Endrin Aldehyde	< 5.0	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	
Endosulfan Sulfate	< 5.0	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	
Methoxychlor	< 5.0	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	AN1
Chlordane	< 25.	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	
Toxaphene	< 25.	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	
Surrogate-TCMX	109	%	EPA 8081B	12/14/21	W DPD	A	
Surrogate-DCB	85	%	EPA 8081B	12/14/21	W DPD	A	
Poly-Chlorinated Biphenyls							
Extraction	Completed		EPA 3545A	12/13/21	W CLD	A	
Aroclor 1016 (PCB-1016)	< 9.6	ug/Kg, dry	EPA 8082A	12/15/21	W DPD	A	
Aroclor 1221 (PCB-1221)	< 9.6	ug/Kg, dry	EPA 8082A	12/15/21	W DPD	A	
Aroclor 1232 (PCB-1232)	< 9.6	ug/Kg, dry	EPA 8082A	12/15/21	W DPD	A	
Aroclor 1242 (PCB-1242)	< 9.6	ug/Kg, dry	EPA 8082A	12/15/21	W DPD	A	
Aroclor 1248 (PCB-1248)	< 9.6	ug/Kg, dry	EPA 8082A	12/15/21	W DPD	A	
Aroclor 1254 (PCB-1254)	< 9.6	ug/Kg, dry	EPA 8082A	12/15/21	W DPD	A	
Aroclor 1260 (PCB-1260)	< 9.6	ug/Kg, dry	EPA 8082A	12/15/21	W DPD	A	
Surrogate-TCMX	74	%	EPA 8082A	12/15/21	W DPD	A	
Surrogate-DCB	99	%	EPA 8082A	12/15/21	W DPD	A	
EPA 8270C Semi-VOA							
Extraction	Completed		EPA 3550C	12/6/21	W EM	A	

Laboratory Report DATE REPORTED: 12/17/2021

CLIENT: Dubois & King, Inc. WORK ORDER: **2112-35270**
PROJECT: Williams Dam DATE RECEIVED: 12/01/2021

001 Site: Bridge Location Date Sampled: 11/30/21 Time: 11:30

Parameter	Result	Units	Method	Analysis Date/Time	Lab/Tech	NELAC	Qual.
N-Nitrosodimethylamine	< 241	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Pyridine	< 482	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Aniline	< 482	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	N	
Bis(2-chloroethyl)ether	< 241	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
1,2-Dichlorobenzene	< 96.4	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
1,3-Dichlorobenzene	< 96.4	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
1,4-Dichlorobenzene	< 96.4	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Benzyl alcohol	< 964	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	N	
2,2'-Oxybis(1-chloropropane)	< 241	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
N-Nitrosodi-n-propylamine	< 482	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Hexachloroethane	< 96.4	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Nitrobenzene	< 241	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
N-Nitrosopiperidine	< 482	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	N	
Isophorone	< 96.4	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Bis(2-chloroethoxy)methane	< 241	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
1,2,4-Trichlorobenzene	< 96.4	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Naphthalene	< 24.1	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
4-Chloroaniline	< 241	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	N	
Hexachlorobutadiene	< 96.4	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
N-Nitrosodi-n-butylamine	< 241	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	N	
2-Methylnaphthalene	< 24.1	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
1-Methylnaphthalene	< 24.1	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	U	
Hexachlorocyclopentadiene	< 964	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
2-Chloronaphthalene	< 96.4	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
1-Chloronaphthalene	< 96.4	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	N	
2-Nitroaniline	< 964	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	N	
Dimethyl phthalate	< 96.4	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
2,6-Dinitrotoluene	< 241	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Acenaphthylene	< 24.1	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
3-Nitroaniline	< 241	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	N	
Acenaphthene	< 24.1	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Dibenzofuran	< 96.4	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	N	
2,4-Dinitrotoluene	< 241	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
1-Naphthylamine	< 482	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	N	
2-Naphthylamine	< 482	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	N	
Fluorene	< 24.1	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Diethyl phthalate	< 241	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
4-Chlorophenyl phenyl ether	< 96.4	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
4-Nitroaniline	< 964	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	N	
N-Nitrosodiphenylamine	< 241	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Azobenzene/1,2-Diphenylhydrazine	< 241	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	U	
4-Bromophenyl phenyl ether	< 96.4	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Hexachlorobenzene	< 48.2	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Phenanthrene	< 24.1	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Anthracene	< 24.1	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Carbazole	< 241	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	N	

Laboratory Report DATE REPORTED: 12/17/2021

CLIENT: Dubois & King, Inc. WORK ORDER: **2112-35270**
PROJECT: Williams Dam DATE RECEIVED: 12/01/2021

001 Site: Bridge Location Date Sampled: 11/30/21 Time: 11:30

Parameter	Result	Units	Method	Analysis Date/Time	Lab/Tech	NELAC	Qual.
Di-n-butylphthalate	< 241	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Fluoranthene	< 24.1	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Benzidine	< 964	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Pyrene	< 24.1	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Butyl benzyl phthalate	< 241	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Benzo(a)anthracene	< 24.1	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Chrysene	< 24.1	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
3,3'-Dichlorobenzidine	< 241	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Bis(2-ethylhexyl)phthalate	< 964	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Di-n-octylphthalate	< 241	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Benzo(b)fluoranthene	< 24.1	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Benzo(k)fluoranthene	< 24.1	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Benzo(a)pyrene	< 12.0	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Indeno(1,2,3-cd)pyrene	< 24.1	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Dibenzo(a,h)anthracene	< 12.0	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Benzo(g,h,i)perylene	< 24.1	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Phenol	< 96.4	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
2-Chlorophenol	< 241	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
2-Methylphenol (o-cresol)	< 241	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
3&4-Methylphenol (m&p-cresol)	< 241	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Cresols, Total	< 482	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	U	
2-Nitrophenol	< 482	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
2,4-Dimethylphenol	< 241	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
2,4-Dichlorophenol	< 241	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
2,6-Dichlorophenol	< 241	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	N	
4-Chloro-3-methylphenol	< 241	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
2,4,5-Trichlorophenol	< 241	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
2,4,6-Trichlorophenol	< 241	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
2,4-Dinitrophenol	< 964	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
4-Nitrophenol	< 241	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
4,6-Dinitro-2-methylphenol	< 964	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Pentachlorophenol	< 482	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
BaP Toxic Equiv. Quotient	< 31.5	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	U	
B/N Surr.1 Nitrobenzene-d5	55	%	EPA 8270D	12/16/21	W EEP	U	
B/N Surr.2 2-Fluorobiphenyl	54	%	EPA 8270D	12/16/21	W EEP	U	
B/N Surr.3 Terphenyl-d14	66	%	EPA 8270D	12/16/21	W EEP	U	
Acid Surr.1 2-Fluorophenol	53	%	EPA 8270D	12/16/21	W EEP	U	
Acid Surr.2 Phenol-d5	58	%	EPA 8270D	12/16/21	W EEP	U	
Acid Surr.3 Tribromophenol	72	%	EPA 8270D	12/16/21	W EEP	U	
Unidentified Peaks	> 10		EPA 8270D	12/16/21	W EEP	U	

002 Site: Hydrant Location Date Sampled: 11/30/21 Time: 12:00

Parameter	Result	Units	Method	Analysis Date/Time	Lab/Tech	NELAC	Qual.
TKN	1,800	mg/Kg, dry	EPA 351.2	12/8/21	N MAP	U	
Phosphorus, Total	570	mg/Kg, dry	EPA 6010C	12/3/21	W FAA	U	

Laboratory Report DATE REPORTED: 12/17/2021

CLIENT: Dubois & King, Inc. WORK ORDER: **2112-35270**
PROJECT: Williams Dam DATE RECEIVED: 12/01/2021

002 Site: Hydrant Location Date Sampled: 11/30/21 Time: 12:00

Parameter	Result	Units	Method	Analysis Date/Time	Lab/Tech	NELAC	Qual.
Mercury Digestion	Digested		EPA 7471B	12/8/21	W FAA	A	
Metals Solids Digestion	Digested		EPA 3050B	12/2/21	W FAA	A	
Arsenic, Total	< 7.5	mg/Kg, dry	EPA 6010C	12/3/21	W FAA	A	
Barium, Total	58	mg/Kg, dry	EPA 6010C	12/3/21	W FAA	A	
Cadmium, Total	< 0.75	mg/Kg, dry	EPA 6010C	12/3/21	W FAA	A	
Chromium, Total	9.7	mg/Kg, dry	EPA 6010C	12/3/21	W FAA	A	
Lead, Total	< 15	mg/Kg, dry	EPA 6010C	12/3/21	W FAA	A	
Mercury, Total	< 0.093	mg/Kg, dry	EPA 7471B	12/9/21	W FAA	A	
Selenium, Total	< 15	mg/Kg, dry	EPA 6010C	12/3/21	W FAA	A	
Silver, Total	< 7.5	mg/Kg, dry	EPA 6010C	12/3/21	W FAA	A	
Oil & Grease	253	mg/Kg, Dry	modified EPA 1664A	12/14/21	W CLD	N	
Volatile Organic Compounds							
Prep EPA 5035A	Complete		EPA 5035A-H	12/1/21	W TRP	A	
Dichlorodifluoromethane	< 1,260	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
Chloromethane	< 1,260	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
Vinyl chloride	< 504	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
Bromomethane	< 1,260	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
Chloroethane	< 1,260	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
Trichlorofluoromethane	< 504	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
Diethyl ether	< 1,260	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
1,1-Dichloroethene	< 252	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
Acetone	< 2,520	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
Carbon disulfide	< 1,260	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
Methylene chloride	< 2,520	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
t-Butanol	< 6,300	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
Methyl-t-butyl ether (MTBE)	< 504	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
trans-1,2-Dichloroethene	< 252	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
Di-isopropyl ether (DIPE)	< 504	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	U	
1,1-Dichloroethane	< 252	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
Ethyl-t-butyl ether (ETBE)	< 504	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	U	
2-Butanone	< 5,040	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
2,2-Dichloropropane	< 252	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
cis-1,2-Dichloroethene	< 252	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
Bromochloromethane	< 504	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
Chloroform	< 252	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
Tetrahydrofuran	< 2,520	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	U	
1,1,1-Trichloroethane	< 252	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
Carbon tetrachloride	< 252	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
1,1-Dichloropropene	< 252	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
Benzene	< 252	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
t-Amylmethyl ether (TAME)	< 504	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	U	
1,2-Dichloroethane	< 252	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
Trichloroethene	< 252	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
1,2-Dichloropropane	< 504	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
Dibromomethane	< 504	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
Bromodichloromethane	< 252	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	

Laboratory Report DATE REPORTED: 12/17/2021

CLIENT: Dubois & King, Inc. WORK ORDER: **2112-35270**
PROJECT: Williams Dam DATE RECEIVED: 12/01/2021

002 Site: Hydrant Location Date Sampled: 11/30/21 Time: 12:00

Parameter	Result	Units	Method	Analysis Date/Time	Lab/Tech	NELAC	Qual.
cis-1,3-Dichloropropene	< 252	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
4-Methyl-2-pentanone (MIBK)	< 2,520	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
Toluene	< 252	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
trans-1,3-Dichloropropene	< 252	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
1,1,2-Trichloroethane	< 252	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
Tetrachloroethene	< 252	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
1,3-Dichloropropane	< 252	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
2-Hexanone	< 2,520	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
Dibromochloromethane	< 252	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
1,2-Dibromoethane	< 504	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
Chlorobenzene	< 252	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
Ethylbenzene	< 252	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
1,1,1,2-Tetrachloroethane	< 504	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
Xylenes, Total	< 504	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
Styrene	< 252	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
Bromoform	< 504	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
Isopropylbenzene	< 252	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
1,1,2,2-Tetrachloroethane	< 504	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
Bromobenzene	< 252	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
n-Propylbenzene	< 504	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
1,2,3-Trichloropropane	< 504	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
2-Chlorotoluene	< 504	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
1,3,5-Trimethylbenzene	< 504	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
4-Chlorotoluene	< 504	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
t-Butylbenzene	< 504	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
1,2,4-Trimethylbenzene	< 504	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
s-Butylbenzene	< 504	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
4-Isopropyltoluene	< 504	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
1,3-Dichlorobenzene	< 504	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
1,4-Dichlorobenzene	< 504	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
1,2,3-Trimethylbenzene	< 504	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
n-Butylbenzene	< 504	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
1,2-Dichlorobenzene	< 504	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
1,2-Dibromo-3-Chloropropane	< 504	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
1,2,4-Trichlorobenzene	< 504	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
1,3,5-Trichlorobenzene	< 504	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
Hexachlorobutadiene	< 504	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
Naphthalene	< 504	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	A	
1,2,3-Trichlorobenzene	< 504	ug/Kg, Dry	EPA 8260C	12/1/21	W TRP	N	
Surr. 1 (Dibromofluoromethane)	106	%	EPA 8260C	12/1/21	W TRP	U	
Surr. 2 (Toluene d8)	101	%	EPA 8260C	12/1/21	W TRP	U	
Surr. 3 (4-Bromofluorobenzene)	100	%	EPA 8260C	12/1/21	W TRP	U	
Unidentified Peaks	0		EPA 8260C	12/1/21	W TRP	U	
TPH-GRO Package							
Prep EPA 5035A High Level	Complete		EPA 5035A-H	12/2/21	W TRP	N	
C5-C10 TPH GRO	< 20.1	mg/Kg, dry	EPA 8260C	12/2/21	W TRP	N	

Laboratory Report DATE REPORTED: 12/17/2021

CLIENT: Dubois & King, Inc. WORK ORDER: **2112-35270**
PROJECT: Williams Dam DATE RECEIVED: 12/01/2021

002 Site: Hydrant Location Date Sampled: 11/30/21 Time: 12:00

Parameter	Result	Units	Method	Analysis Date/Time	Lab/Tech	NELAC	Qual.
> C10 Volatile Hydrocarbons	< 20.1	mg/Kg, dry	EPA 8260C	12/2/21	W TRP	U	
TPH DRO Package							
Extraction	Completed		EPA 3550C	12/10/21	W EM	A	
C7-C10 TPH	< 41.4	mg/Kg, dry	EPA 8015D	12/13/21	W DPD	U	
C10-C28 TPH-DRO	45.7	mg/Kg, dry	EPA 8015D	12/13/21	W DPD	A	
C28-C40 TPH	43.3	mg/Kg, dry	EPA 8015D	12/13/21	W DPD	U	
Tot. Petroleum Hydrocarbons	89.1	mg/Kg, dry	EPA 8015D	12/13/21	W DPD	U	
Hydrocarbon Window	C14-C34		EPA 8015D	12/13/21	W DPD	U	
Priority Pollutant Pesticides							
Extraction	Completed		EPA 3545A	12/13/21	W CLD	A	
alpha-BHC	< 6.4	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	
gamma-BHC (Lindane)	< 6.4	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	
beta-BHC	< 6.4	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	
delta-BHC	< 6.4	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	
Heptachlor	< 6.4	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	
Aldrin	< 6.4	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	
Heptachlor Epoxide	< 6.4	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	
4,4'-DDE	< 6.4	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	
Endosulfan I	< 6.4	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	
Dieldrin	< 6.4	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	
Endrin	< 6.4	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	
4,4'-DDD	< 6.4	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	
Endosulfan II	< 6.4	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	
4,4'-DDT	< 6.4	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	AN1
Endrin Aldehyde	< 6.4	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	
Endosulfan Sulfate	< 6.4	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	
Methoxychlor	< 6.4	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	AN1
Chlordane	< 31.9	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	
Toxaphene	< 31.9	ug/Kg, dry	EPA 8081B	12/14/21	W DPD	A	
Surrogate-TCMX	74	%	EPA 8081B	12/14/21	W DPD	A	
Surrogate-DCB	71	%	EPA 8081B	12/14/21	W DPD	A	
Poly-Chlorinated Biphenyls							
Extraction	Completed		EPA 3545A	12/13/21	W CLD	A	
Aroclor 1016 (PCB-1016)	< 12.8	ug/Kg, dry	EPA 8082A	12/15/21	W DPD	A	
Aroclor 1221 (PCB-1221)	< 12.8	ug/Kg, dry	EPA 8082A	12/15/21	W DPD	A	
Aroclor 1232 (PCB-1232)	< 12.8	ug/Kg, dry	EPA 8082A	12/15/21	W DPD	A	
Aroclor 1242 (PCB-1242)	< 12.8	ug/Kg, dry	EPA 8082A	12/15/21	W DPD	A	
Aroclor 1248 (PCB-1248)	< 12.8	ug/Kg, dry	EPA 8082A	12/15/21	W DPD	A	
Aroclor 1254 (PCB-1254)	< 12.8	ug/Kg, dry	EPA 8082A	12/15/21	W DPD	A	
Aroclor 1260 (PCB-1260)	< 12.8	ug/Kg, dry	EPA 8082A	12/15/21	W DPD	A	
Surrogate-TCMX	69	%	EPA 8082A	12/15/21	W DPD	A	
Surrogate-DCB	96	%	EPA 8082A	12/15/21	W DPD	A	
EPA 8270C Semi-VOA							
Extraction	Completed		EPA 3550C	12/6/21	W EM	A	
N-Nitrosodimethylamine	< 318	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Pyridine	< 637	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	

Laboratory Report DATE REPORTED: 12/17/2021

CLIENT: Dubois & King, Inc. WORK ORDER: **2112-35270**
PROJECT: Williams Dam DATE RECEIVED: 12/01/2021

002 Site: Hydrant Location Date Sampled: 11/30/21 Time: 12:00

Parameter	Result	Units	Method	Analysis Date/Time	Lab/Tech	NELAC	Qual.
Aniline	< 637	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	N	
Bis(2-chloroethyl)ether	< 318	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
1,2-Dichlorobenzene	< 127	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
1,3-Dichlorobenzene	< 127	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
1,4-Dichlorobenzene	< 127	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Benzyl alcohol	< 1,270	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	N	
2,2'-Oxybis(1-chloropropane)	< 318	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
N-Nitrosodi-n-propylamine	< 637	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Hexachloroethane	< 127	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Nitrobenzene	< 318	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
N-Nitrosopiperidine	< 637	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	N	
Isophorone	< 127	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Bis(2-chloroethoxy)methane	< 318	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
1,2,4-Trichlorobenzene	< 127	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Naphthalene	< 31.8	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
4-Chloroaniline	< 318	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	N	
Hexachlorobutadiene	< 127	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
N-Nitrosodi-n-butylamine	< 318	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	N	
2-Methylnaphthalene	< 31.8	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
1-Methylnaphthalene	< 31.8	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	U	
Hexachlorocyclopentadiene	< 1,270	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
2-Chloronaphthalene	< 127	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
1-Chloronaphthalene	< 127	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	N	
2-Nitroaniline	< 1,270	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	N	
Dimethyl phthalate	< 127	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
2,6-Dinitrotoluene	< 318	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Acenaphthylene	< 31.8	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
3-Nitroaniline	< 318	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	N	
Acenaphthene	< 31.8	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Dibenzofuran	< 127	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	N	
2,4-Dinitrotoluene	< 318	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
1-Naphthylamine	< 637	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	N	
2-Naphthylamine	< 637	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	N	
Fluorene	< 31.8	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Diethyl phthalate	< 318	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
4-Chlorophenyl phenyl ether	< 127	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
4-Nitroaniline	< 1,270	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	N	
N-Nitrosodiphenylamine	< 318	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Azobenzene/1,2-Diphenylhydrazine	< 318	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	U	
4-Bromophenyl phenyl ether	< 127	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Hexachlorobenzene	< 63.7	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Phenanthrene	< 31.8	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Anthracene	< 31.8	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Carbazole	< 318	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	N	
Di-n-butylphthalate	< 318	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Fluoranthene	< 31.8	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	

Laboratory Report DATE REPORTED: 12/17/2021

CLIENT: Dubois & King, Inc. WORK ORDER: **2112-35270**
PROJECT: Williams Dam DATE RECEIVED: 12/01/2021

002 | Site: Hydrant Location Date Sampled: 11/30/21 Time: 12:00

Parameter	Result	Units	Method	Analysis Date/Time	Lab/Tech	NELAC	Qual.
Benzidine	< 1,270	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Pyrene	< 31.8	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Butyl benzyl phthalate	< 318	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Benzo(a)anthracene	< 31.8	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Chrysene	< 31.8	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
3,3'-Dichlorobenzidine	< 318	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Bis(2-ethylhexyl)phthalate	< 1,270	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Di-n-octylphthalate	< 318	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Benzo(b)fluoranthene	< 31.8	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Benzo(k)fluoranthene	< 31.8	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Benzo(a)pyrene	< 15.9	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Indeno(1,2,3-cd)pyrene	< 31.8	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Dibenzo(a,h)anthracene	< 15.9	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Benzo(g,h,i)perylene	< 31.8	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Phenol	< 127	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
2-Chlorophenol	< 318	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
2-Methylphenol (o-cresol)	< 318	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
3&4-Methylphenol (m&p-cresol)	< 318	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Cresols, Total	< 637	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	U	
2-Nitrophenol	< 637	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
2,4-Dimethylphenol	< 318	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
2,4-Dichlorophenol	< 318	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
2,6-Dichlorophenol	< 318	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	N	
4-Chloro-3-methylphenol	< 318	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
2,4,5-Trichlorophenol	< 318	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
2,4,6-Trichlorophenol	< 318	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
2,4-Dinitrophenol	< 1,270	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
4-Nitrophenol	< 318	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
4,6-Dinitro-2-methylphenol	< 1,270	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
Pentachlorophenol	< 637	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	A	
BaP Toxic Equiv. Quotient	< 41.7	ug/Kg, dry	EPA 8270D	12/16/21	W EEP	U	
B/N Surr.1 Nitrobenzene-d5	61	%	EPA 8270D	12/16/21	W EEP	U	
B/N Surr.2 2-Fluorobiphenyl	70	%	EPA 8270D	12/16/21	W EEP	U	
B/N Surr.3 Terphenyl-d14	84	%	EPA 8270D	12/16/21	W EEP	U	
Acid Surr.1 2-Fluorophenol	64	%	EPA 8270D	12/16/21	W EEP	U	
Acid Surr.2 Phenol-d5	72	%	EPA 8270D	12/16/21	W EEP	U	
Acid Surr.3 Tribromophenol	96	%	EPA 8270D	12/16/21	W EEP	U	
Unidentified Peaks	> 10		EPA 8270D	12/16/21	W EEP	U	

Laboratory Report DATE REPORTED: 12/17/2021

CLIENT: Dubois & King, Inc. WORK ORDER: **2112-35270**
PROJECT: Williams Dam DATE RECEIVED: 12/01/2021

Report Summary of Qualifiers and Notes

GRO values are based on the response and calibration of Unleaded Gasoline.

VOC results below 200 ug/Kg may be biased low due to sample preparation by 5035A High method.

DRO values are based on the response and calibration of Diesel/#2 Fuel Oil.

AN1: Instrument performance degraded during the analytical sequence due to the nature of the samples analyzed. Result of the closing calibration check standard was below method control limits for this parameter. Reported result may be biased low.

Appendix D

Hydraulic Modeling Exhibits

Figure 1

Existing Conditions
10-Yr Water Depth

Williams Dam Study
(#115.01)

Town of Londonderry
100 Old School Street
S. Londonderry
VT 05155

Legend

Existing 10-Yr Flood Depth

Value

High : 18.4 ft

Low : 0.01 ft

0 0.0125 0.025 0.05
Miles

DuBois & King inc.

Prepared by: R. Lanzilotta, 1-28-2022 Checked by: C. Johnston, 1-28-2022

Figure 2

Alt 1 Dam Removal
10-Yr Water Depth

Williams Dam Study
(#115.01)

Town of Londonderry
100 Old School Street
S. Londonderry
VT 05155

Legend

Removal 10-Yr Flood Depth

Value

High : 11.8

Low : 0.01

0 0.0125 0.025 0.05
Miles

DuBois & King inc.

Prepared by: R. Lanzilotta, 2-8-2022 Checked by: C. Johnston, 2-8-2022

Figure 3

Alt 2 Dam Replacement
10-Yr Water Depth

Williams Dam Study
(#115.01)

Town of Londonderry
100 Old School Street
S. Londonderry
VT 05155

Legend

Replacement 10-Yr Flood Depth

Value

High : 18.0

Low : 0.01

0 0.0125 0.025 0.05
Miles

DuBois & King inc.

Prepared by: R. Lanzilotta, 2-8-2022 Checked by: C. Johnston, 2-8-2022

Figure 4

Existing Conditions
100-Yr Water Depth

Williams Dam Study
(#115.01)

Town of Londonderry
100 Old School Street
S. Londonderry
VT 05155

Legend

Existing 100-yr Flood Depth

Value

High : 22.2 ft

Low : 0.01 ft

0 0.0125 0.025 0.05
Miles

DuBois & King inc.

Prepared by: R. Lanzilotta, 2-1-2022 Checked by: C. Johnston, 2-1-2022

Figure 5

Alt 1 Dam Removal
100-Yr Water Depth

Williams Dam Study
(#115.01)

Town of Londonderry
100 Old School Street
S. Londonderry
VT 05155

Legend

Removal 100-Yr Flood Depth

Value

High : 16.4

Low : 0.01

0 0.0125 0.025 0.05
Miles

DuBois & King inc.

Prepared by: R. Lanzilotta, 2-8-2022 Checked by: C. Johnston, 2-8-2022

Figure 6

Alt 2 Dam Replacement
100-Yr Water Depth

Williams Dam Study
(#115.01)

Town of Londonderry
100 Old School Street
S. Londonderry
VT 05155

Legend

Replacement 100-Yr Flood Depth

Value

High : 21.4

Low : 0.01

0 0.0125 0.025 0.05
Miles

DuBois & King inc.

Prepared by: R. Lanzilotta, 2-8-2022 Checked by: C. Johnston, 2-8-2022

Appendix E

Vermont Dam Safety - Williams Dam Failure Analysis and Hazard Potential Classification Study

Vermont Department of Environmental Conservation
Agency of Natural Resources
Water Investment Division
1 National Life Drive, Davis 3
Montpelier, VT 05620
Phone: 802-622-4093

MEMORANDUM

TO:	Town of Londonderry – Dam Owner Charles Johnston, PE, Dubois & King, Inc.
FROM:	Benjamin Green, PE, VTDEC Dam Safety Program (DSP) - Dam Safety Engineer Andrew Sampsell, DSP - Dam Safety Engineer
DATE:	March 2nd, 2022
SUBJECT:	DSS-Wise Lite Dam Failure Analysis and Hazard Potential Classification Study Williams Dam, Londonderry, Vermont State ID No: 115.01, National ID: VT00257

This memorandum summarizes the methods, assumptions, and results of a simplified dam failure and downstream flood inundation analysis using the Decision System for Water Infrastructural Security (DSS-Wise Lite) model for the Williams Dam located in Londonderry, VT. The following attachments are included for the modeling scenario that controlled the hazard potential classification selection for the dam:

- ***Attachment A:*** Flood Inundation Map
- ***Attachment B:*** DSS-Wise Lite Reservoir Simulation Results
- ***Attachment C:*** DSS-Wise Lite Reservoir Simulation Human Consequences Final Report

It should be noted that ***Attachments B*** and ***C*** are automatically generated reports by the DSS-Wise Lite Program.

Purpose:
The analysis was performed to investigate the hazard potential classification of the dam and to gain a greater understanding of the potential ranges of consequences of a dam failure or incident. Updated hazard potential classification review is needed for many dams in the State's inventory due to the adoption of new definitions and processes in the Dam Safety Rules and the potential for downstream development that could impact classification. This analysis will evaluate the hazard potential classification using a simplified procedure and publicly available data. In addition, it is our hope that the flood inundation map generated from this work can be used in future emergency action planning for the dam.

Dam Overview:
Williams Dam is a run-of-the-river stone masonry and concrete gravity dam with an outlet gate that is currently classified as a LOW hazard potential dam. A dam at the site dates back to at least 1900 and likely earlier. The last documented rehabilitation of the dam was in 1978 when the gate structure was installed and repairs were made to address damages from the 1976 flood. The dam is located just downstream of the VT Route 11 Bridge. The dam was last inspected by the DSP in August 2015 and was found to be in POOR condition. The dam spans approximately 90 feet across the West River (from abutment to abutment). The 90-foot length includes an approximately 73 foot long broad-crested weir principal spillway with the remaining 14 feet being the concrete framed gate structure. The dam appears to be founded on bedrock. At the right abutment is a concrete training wall that extends from the gate approximately 15 feet upstream to the VT Route 11 Bridge. The left abutment contacts a bedrock outcrop adjacent to Edge Hill Road. The height of the dam from the downstream channel invert to the principal spillway crest is approximately 13 feet and to the top of the gate structure or dam crest is about 17 feet per recent survey. Based on USGS StreamStats, the drainage area of the West River at the dam is approximately 40.8 square miles.

Downstream Conditions:
Williams Dam is located on the West River which flows through the Town of Londonderry. Utley Brook, which has a drainage area of approximately 27.7 square miles (USGS StreamStats), joins the West River approximately 1,900 feet downstream of Williams Dam. The West River flows South alongside Route 100 until it reaches Main Street in the Town of South Londonderry where Route 100 diverges west, while the West River continues south. After flowing through the Town of South Londonderry, the floodplain becomes less developed, until the West River reaches the US Army Corps of Engineers Ball Mountain Flood Control Dam located between Winhall Brook Campground and Jamaica State Park. The Ball Mountain Dam is approximately 7.3 miles downstream of Williams Dam. The drainage area of the West River at the Ball Mountain Dam is approximately 169.0 square miles according to USGS StreamStats.

Background / Supporting Data:
The Town of Londonderry recently contracted with the consulting engineering firm Dubois & King, Inc. (D&K) to analyze potential alternatives to either rehabilitate or remove the dam. As part of the alternatives study, D&K was able to collect limited bathymetry and sediment probing data that was provided to the DSP. Outside field survey limits, D&K relied on LIDAR, FEMA Flood Insurance Study (FIS) data, and design plans for the VT Route 11 Bridge to develop a reasonable estimate of reservoir storage volume. Table 1, below, summarizes elevation and estimated storage data.

Table 1: Elevation and Storage Data

	Elevation	Impoundment Surface Area	Sediment Volume[1]	Total Storage Volume[1,2]
	NAVD88 FT	Acres	Acre-ft	Acre-ft
Downstream Channel Invert	1,129	0	0	0
Principal Spillway Crest	1,142	9.3	3.8	24.2
Top of Dam (Top of gate structure)	1,146	29.9	3.8	97.1
Low Chord of VT RT 11 Bridge	1,150	41.8	3.8	244.7

[1] Sediment and total storage volumes are estimates based on the combination of field measurements and available mapping.
[2] Includes estimated volume of sediment storage behind the dam.

Hydrologic and Hydraulic Methods:
The DSP prepared six DSS-Wise Lite simulations/scenarios of the Williams Dam and the downstream floodplain in order to evaluate the dam's hazard potential classification. DSS-Wise Lite is a publicly available flood modeling and consequence analysis tool developed by The National Center for Computational Hydroscience and Engineering at the University of Mississippi. DSS-Wise Lite is a web-based program that allows the user to setup an automated two-dimensional dam failure model with minimal inputs and provides results including inundation maps, flood arrival times, hydrographs, and other life consequence information. As noted in program literature, DSS-Wise Lite is a simplified analysis producing rough, approximate results that are not intended to replace more detailed modeling processes/programs. The following key limitations of DSS-Wise Lite should be understood, additional limitations are described in the user's manual and technical documentation:

- The model relies on a national LIDAR digital elevation model (DEM). The resolution of the DEMs used in the model is 1 meter by 1 meter (3.281 feet). The user has no ability to edit or correct the elevations of the LIDAR DEM outside of inputting the dam structure and levees.
- The model relies on a national land cover dataset to approximate roughness coefficients of the stream channel and floodplain for use in the hydraulic computations. The resolution of the national land cover data base in 30 meters by 30 meters (98.4 feet).
- The smallest cell size for the computation mesh used to perform the 2D hydraulic calculations is 15 feet by 15 feet. Limitations with this cell size, for example, are that it could prevent the model from accurately representing cases with dramatic elevations changes in a small horizontal distance or cases where varying roughness values apply within one cell.
- Large bridges can be input in the model but are modeled as an opening with no bridge deck. The program does not allow for the modeling of culverts at downstream road crossings.
- As with any dam failure analysis, the model relies on the input values of normal and maximum pool storage in the reservoir. In many cases, these values may be rough estimates based on measurements from maps or coarse

field measurements, followed by the application of empirical equations, which may or may not accurately represent the actual storage volume that could be lost during a dam failure.

- The model performs the hydraulic computations using the 2D Shallow Water Equations, which assume a hydrostatic pressure distribution within the water column. This assumption becomes invalid in areas with steep slopes or vertical drops (i.e. calculations in steeply graded flow areas potentially have a higher error).
- No detailed/site specific hydrology besides estimating peak flows using rudimentary methods were performed in this simplified analysis. Since development of a detailed unsteady flood hydrograph is beyond the scope of this analysis, a simplified unsteady flood hydrograph is used that combines steady state peak flows during Storm Day conditions with a basic dam failure flood hydrograph.
- The model is limited to a single discharge input location, which is at the dam/origin of the dam failure. This limitation means that lateral inflows from downstream tributaries during flooding conditions cannot be included in the model. Due to this limitation, "Storm Day" failure analysis comparisons may be limited in ability to accurately represent flooding elevations during regional storm events. The further downstream from the dam, the greater the potential for model error due to the inability to account for flood flow in other tributaries.

Model Scenarios:
Table 2, below, outlines each of the six scenarios modeled for Williams Dam using DSS-Wise Lite. For each selected starting water level/flow condition at the dam, the model was run assuming "no dam failure" and then with "dam failure" to gain an understanding of the potential impacts and incremental consequences of dam failure over baseline flooding in the river.

Table 2: Dam Failure Analysis Scenarios

No.	Scenario	Water Surface Elev. at Start of Simulation (feet)[1]	Failure Type	DSS-Wise Failure Method	Base River Flow
1	Sunny Day - No Dam Failure	1,143	No Failure	Specified Hydrograph	~260 cfs [2]
2	Sunny Day - Dam Failure	1,143	Froehlich Piping Failure	Specified Hydrograph	~260 cfs [2]
3	Storm Day - No Dam Failure	1,146	No Failure	Specified Hydrograph	~1,620 cfs [2]
4	Storm Day - Dam Failure	1,146	Froehlich Piping Failure	Specified Hydrograph	~1,620 cfs [2]
5	Storm Day - No Dam Failure	1,150	No Failure	Specified Hydrograph	~ 11,500 cfs [3]
6	Storm Day - Dam Failure	1,150	Froehlich Piping Failure	Specified Hydrograph	~ 11,500 cfs [3]

[1] Water levels at El. 1,143 represents approximately 1 foot of flow over the principal spillway weir, while E. 1,146 and El. 1,150 represent 4 feet of flow and water levels at the dam crest and 8 feet of flow and water levels at the low chord of the VT Route 11 Bridge, respectively.
[2] Base river discharges were computed using the weir equation and a discharge coefficient of ~2.9 to determine the amount of flow at the dam required to achieve the specified elevation in column 3.
[3] The 100-yr flood discharge from the FEMA Flood Insurance Study was modeled based on the historic LOW hazard potential classification of the Williams Dam. Based on FEMA 100-yr floodplain mapping, the 100-yr flood results in water flowing out of the channel and around the VT Route 11 Bridge and the dam. The DSP decided to limit the reservoir elevation at time of failure to the low chord elevation of the bridge (El. 1,150).

Dam failure parameters were calculated based on the geometry, material composition, and reservoir storage capacity using the Froehlich 2008 method. The Froehlich 2008 method estimates failure parameters using empirical equations developed from past dam failure case study data. The computed failure parameters were then included in a US Army Corps of Engineers (USACE) HEC-HMS hydrologic model to compute a dam failure outflow hydrograph for use in DSS-Wise Lite. A summary of key failure parameters and resulting peak outflow for each failure scenario is provided in Table 3 below. A sensitivity analysis of the range of potential failure parameters was not completed and is beyond the scope of this study.

Table 3: Dam Failure Parameters and Peak Outflow

Scenario	Bottom Opening Width	Formation Time	Piping Coefficient	Peak Discharge
	ft	hrs		cfs
2 - Sunny Day (El. 1,143)	33	0.2	0.6	4,435
4 - Storm Day (El. 1,146)	40	0.2	0.6	8,712
6 - Storm Day (El. 1,150)	60	0.2	0.6	18,182

In the non-failure scenarios, a 24-hour steady state discharge hydrograph representing the base river flow was input into the model immediately downstream of the dam. In the dam failure scenarios, a 6-hour steady state base river flow was input immediately downstream of the dam to "prime" the downstream channel before the unsteady dam failure hydrograph occurred. The steady state discharge was set to continue following the dam failure hydrograph until flood waters reached the model end point (Ball Mountain Flood Control Dam).

Hazard Potential Classification Definitions and Guidance:
Hazard potential classification for dams in Vermont is determined in accordance with the Dam Safety Rules (effective August 1, 2020). Hazard potential classification definitions for HIGH, SIGNIFICANT, and LOW Hazard dams and guidance for evaluating the four main loss types caused by dam failure (direct loss of life, property loss, lifeline loss and environmental loss) are provided in the Rule at the following link: https://dec.vermont.gov/water-investment/dam-safety/dam-safety-statute-and-rules. Of particular interest are the definitions of the hazard potential classification definitions considered for Williams Dam:

HIGH Hazard Potential Dam mean dams where failure or mis-operation will probably cause loss of human life.

SIGNIFICANT Hazard Potential Dam means dams where failure or mis-operation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

LOW Hazard Potential Dam means dams where failure or mis-operation results in no probable loss of human life and low economic and environmental losses.

Model Results and Hazard Potential Classification:
The DSS-Wise Lite model results are summarized in ***Attachments A*** through ***C***. The dam failure flood results were compared to the potential loss types as required by the Dam Safety Rule.

Direct Loss of Life:
Loss of Life was evaluated in reference to criteria established in Downstream Hazard Classification Guidelines developed by the US Bureau of Reclamation in 1988 (ACER Technical Memorandum No. 11). For Williams Dam, Direct Loss of Life focuses on life loss potential of people inside structures at the time of the dam failure. While there is a possibility people could be caught outside within the flood inundation area during a dam failure, in this case, it is reasonable to assume that they would be able to self-evacuate to higher ground. The following two figures depict estimated dam failure flood flow depths and velocities and resulting loss of life potential during dam failure versus non-failure for each of the scenarios at the top four impacted downstream structures. The top four impacted downstream structures are located just downstream of the dam and include the following commercial buildings:

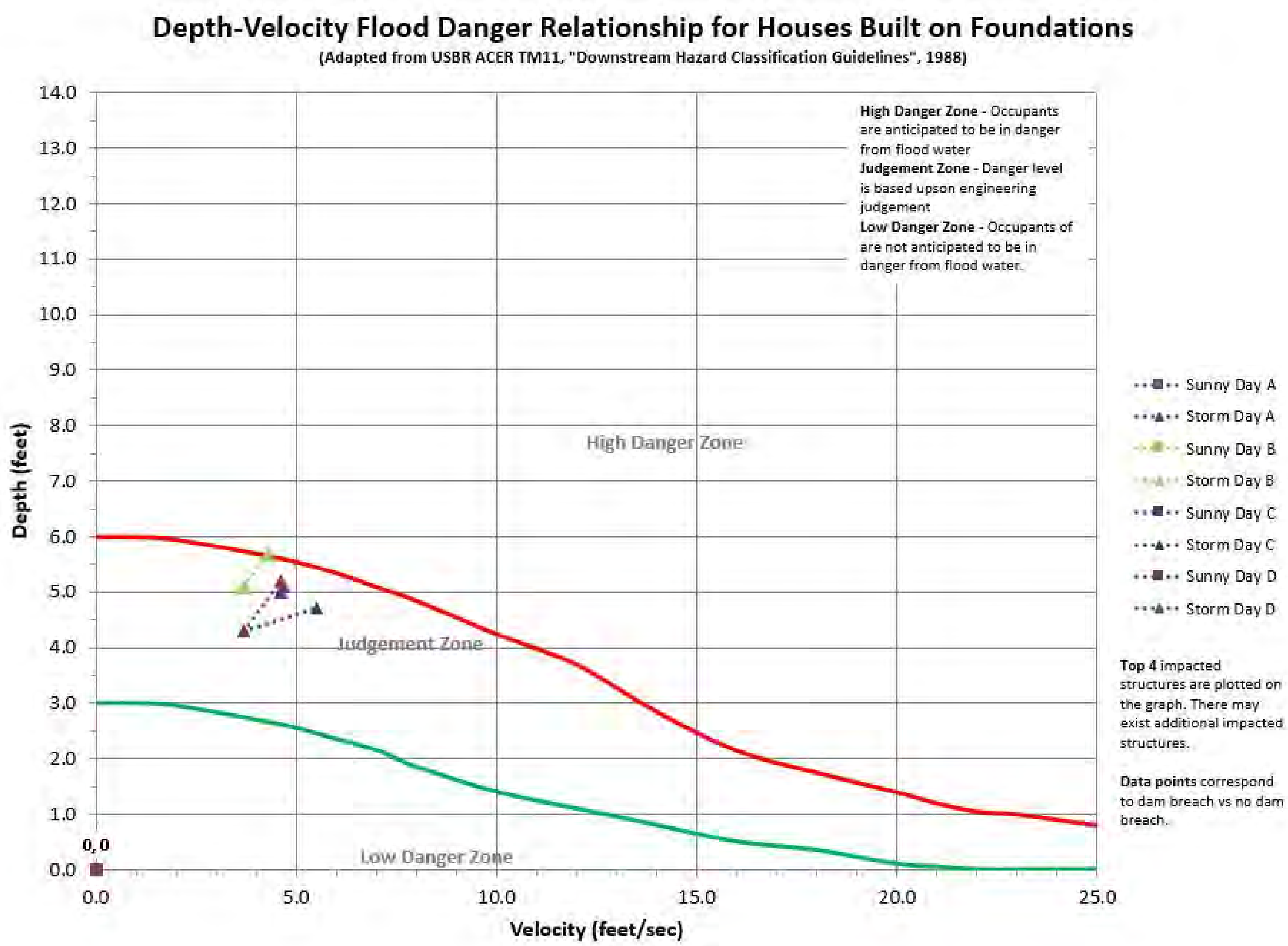
- 2136 North Main Street – Garden Café and Gallery - (A)
- Route 11, 2116 North Main Street – Garden Market - (B)
- 2170/2180 North Main Street – Maple Leaf Diner and Main Street Market and Deli – (C)
- 2152 North Main Street – unknown – (D)

Depths were evaluated above the first-floor elevation of buildings. For this simplified analysis, it was assumed that the first-floor elevations of buildings were 1 foot above the LIDAR DEM elevation around the footprint of the building.

During Scenarios 1/2 (El. 1,143 Sunny Day Baseflow Failure/Non-Failure), when comparing flood depth and velocity combinations at buildings within the downstream floodplain, there appears to be no difference in potential for life loss as no structures are anticipated to experience flooding above their first-floor elevation, whether under non-failure or failure conditions. Accordingly, it is anticipated there would be no direct loss of life from this scenario.

Similarly, during Scenarios 5/6 (El. 1,150 Storm Day Failure/Non-Failure), comparing flood depth and velocity combinations at buildings within the downstream floodplain indicates there is only minor differences between non-failure and failure conditions. While depth and velocity combinations are potentially hazardous at the four structures (depths in the 4-to-5-foot range, velocities in the 3 to 5 ft/s range and plot in the "Judgement Zone"), the incremental increase in flood depth and velocities from dam failure over baseline flooding appears limited to generally less than 1 foot and 1 ft/s and values remain plotted in the "Judgment Zone" as opposed to the "High Danger Zone". Accordingly, the potential risk to life is present during the flood/non-failure condition and not measurably worsened by dam failure. Therefore, loss of life during this scenario <u>due to dam failure</u> is not considered probable. See the plot below that shows flood depth and velocity combinations during this scenario under non-failure and failure flows and the minor incremental increases due to failure.

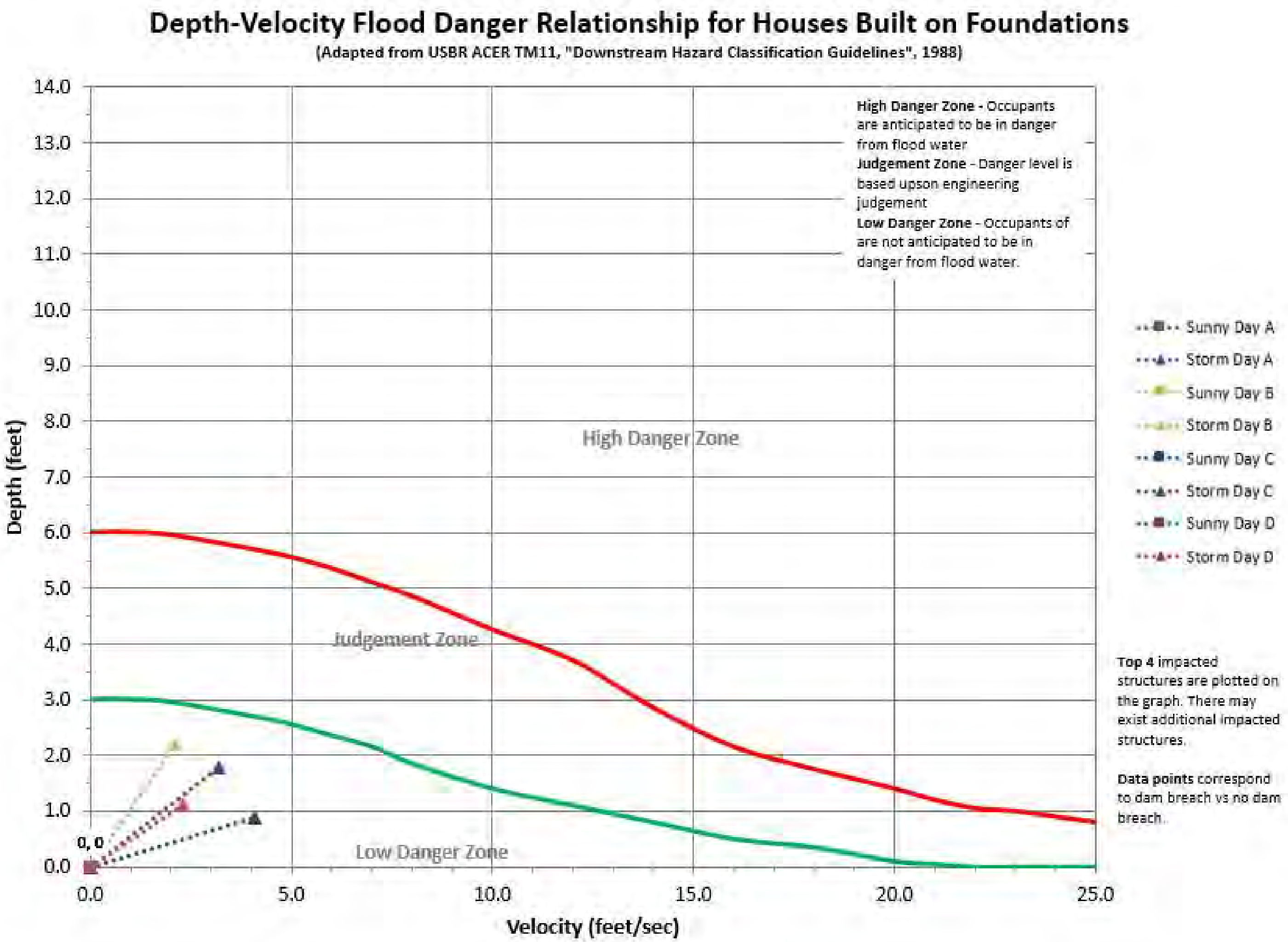
Figure 1: USBR ACER No. 11 Life loss Potential (Scenario 5/6, El. 1,150 Storm Day Comparison)



However, Scenarios 3/4 (El. 1,146 Storm Dam Non-Failure/Failure) appear to control in terms of potential for damages and direct loss of life due to the failure of Williams Dam. The Human Consequences Report (HCOM) module within DSS-Wise for these scenarios provides an estimated range of Population at Risk (PAR), which is defined as the estimated number of people located within the inundation limits of a simulated dam failure (not necessarily the number of potential fatalities, as depths and velocities within the inundation extents can range from little to no impact/non-life threatening to life threatening). While PAR is not specifically used for hazard potential classification, understanding the potential range of PAR for a dam failure can be useful in emergency planning. The estimated PAR for Williams Dam could range from approximately 10 to 50 people .

In comparing flood depth and velocity combinations at buildings within the downstream floodplain, there appears to be notable differences between non-failure and failure conditions. While depth and velocity combinations under non-failure conditions do not appear to be potentially hazardous as no buildings are flooded, the incremental increase in flood depth and velocities from dam failure over baseline flooding appears to range from 1 to 2 feet and 2 to 4 ft/s above estimated first floor elevations. However, these increased depths and velocities still plot within the Low Danger zone of the ACER plot, indicating that loss of life during this scenario due to dam failure, is also not considered probable. See the plot below that shows flood depth and velocity combinations during this scenario under non-failure and failure flows and the incremental increases due to failure.

Figure 2: USBR ACER No. 11 Life loss Potential (Scenario 3/4, El. 1,146 Storm Day Comparison)



Based on these results, the potential for direct loss of life due to a failure of Williams Dam does not appear probable. Accordingly, based on this analysis, the hazard potential classification of HIGH is eliminated from consideration and the hazard potential classification of SIGNIFICANT shall be considered through the evaluation of potential property, lifeline, and environmental losses, below.

Property Losses:
Based on reviewing the potential for property damage to occur (using DSS-Wise Results, Orthoimagery, and LIDAR elevation data) it was found that Scenarios 3/4 (El. 1,146 Storm Dam Non-Failure/Failure), as was noted above, are the controlling scenarios. The total number of impacted structures for each scenario is presented in Table 4 below. An estimated total of 11 structures, including mainly commercial buildings and several homes are impacted as a result of the flood flows plus dam failure, versus 0 for non-failure conditions. Flooding depths at these structures attributed to dam failure ranged from less than one foot to approximately 3 feet adjacent to the structures and multiple structures were surrounded by flooding. As a result, it is anticipated that property damage would occur to these structures as flooding up to 2 feet above first floor elevations could be realized.

Scenario	Number of Impacted Structures
1 - Sunny Day (El. 1,143) Non-Failure	0
2 - Sunny Day (El. 1,143) Dam Failure	5
3 - Storm Day (El. 1,146) Non-Failure	*0*
4 - Storm Day (El. 1,146) Dam Failure	*11*
5 - Storm Day (El. 1,150) Non-Failure	37
6 - Storm Day (El. 1,150) Dam Failure	37

Based on these results, the potential for property losses due to a failure of Williams Dam appear to be fairly extensive to occupied buildings. Accordingly, based on this analysis, the hazard potential classification of at least SIGNIFICANT is considered appropriate due to the potential for property loss.

Lifeline Losses:
Under the Dam Safety Rules, the hazard potential classification cannot be increased above SIGNIFICANT as a result of lifeline losses. Therefore, since property losses already drives the hazard potential classification to SIGNIFICANT, lifeline losses are not considered a hazard classification driver. However, it should be noted that during Scenario 4, VT Route 11 (North Main Street) would overtop due to dam failure to a depth of approximately 1.5 feet and velocity of 3 ft/s. The overtopping location is in the vicinity of 2180 North Main Steet. It is anticipated that these depth and velocity combinations could cause some damage to the roadway. No other bridge/roadway overtopping locations were identified during this scenario.

Environmental Losses:
Similarly to Lifeline Losses, above, the hazard potential classification cannot be increased above SIGNIFICANT as a result of environmental losses, so environmental losses are not considered a hazard classification driver. It should be noted that D&K has estimated that approximately 3.8 acre-feet of sediment is impounded by the dam, which could be potentially released in the event of a dam failure, stressing water quality and habitat in downstream areas.

Conclusions:
Based on this analysis, the hazard potential classification of Williams Dam should be increased from LOW to SIGNIFICANT based on the potential for property losses in the event of a dam failure. SIGNIFICIANT hazard potential dams are subject to additional requirements over LOW hazard potential dams, including more frequent inspections, Emergency Action Planning requirements, and compliance with more rigorous design and construction standards.

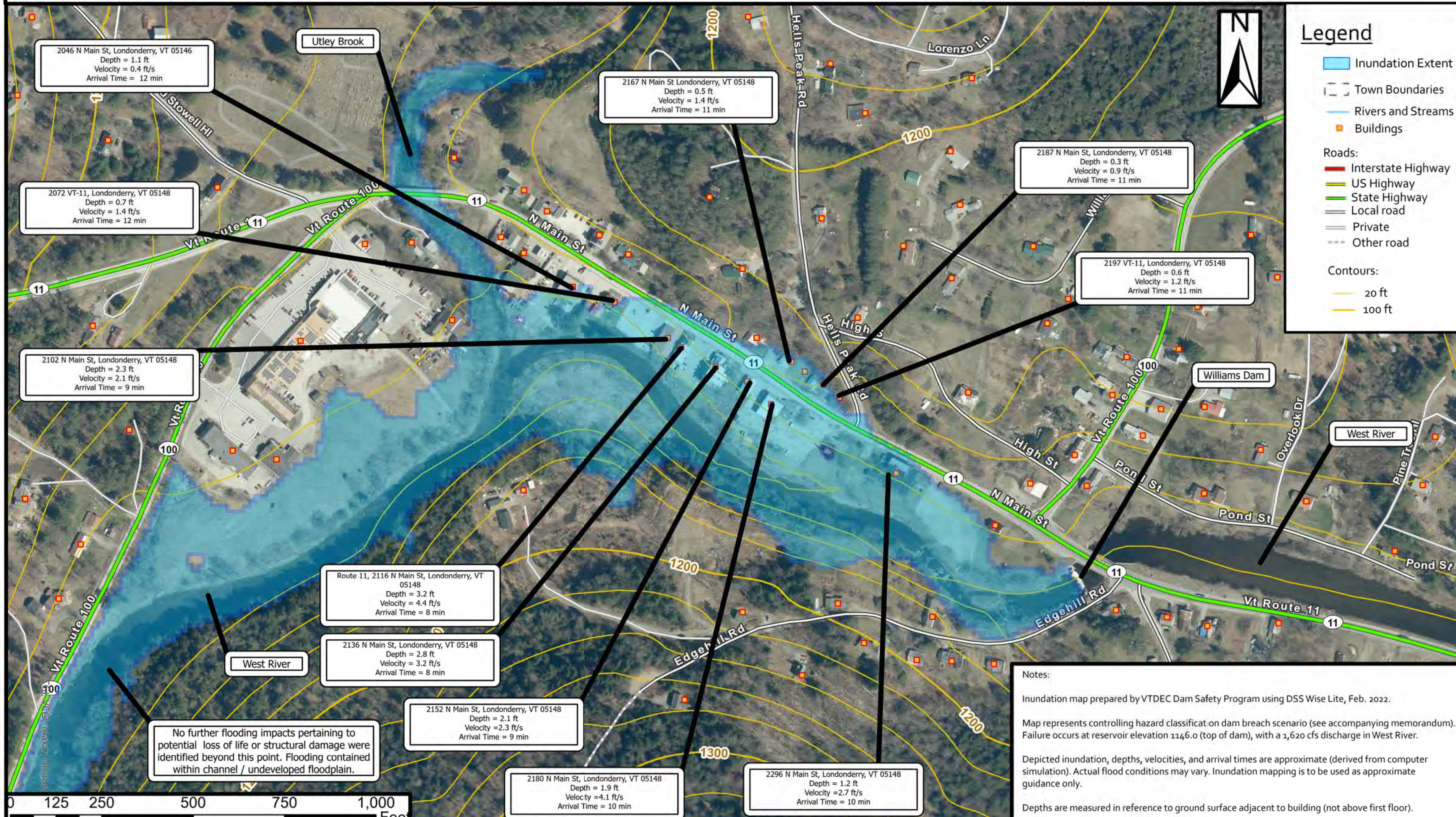
The DSP recommends that the dam owner develop an Emergency Action Plan (EAP) for the dam, using the flood inundation map attached here-in. We would also be happy to provide a copy of the current EAP template for SIGNIFICANT hazard potential dams. EAPs are documents that include pre-planned actions in the case of a dam incident or failure and identify key emergency personnel as well as potential evacuation areas for emergency response planning.

This analysis used simplified methods, assumptions, and techniques, and focused on a limited number of dam failure and flooding scenarios. It is possible that additional losses could be realized in a scenario or flow condition that was not considered in this study. It is recommended to apply caution and conservancy when using the results of this simplified analysis for decision making and emergency action planning. If the dam owner disagrees with the classification assigned based on this study, they may apply to the DSP to reconsider the classification in accordance with Dam Safety Rule, 37-109(5) Hazard Potential Reconsideration.

ARR?AFKCLR A

Williams Dam (No. 115.01) - Londonderry, VT - Flood Inundation Map

Vermont Agency of Natural Resources - Department of Environmental Conservation - Dam Safety Program



Notes:

Inundation map prepared by VTDEC Dam Safety Program using DSS Wise Lite, Feb. 2022.

Map represents controlling hazard classification dam breach scenario (see accompanying memorandum). Failure occurs at reservoir elevation 1146.0 (top of dam), with a 1,620 cfs discharge in West River.

Depicted inundation, depths, velocities, and arrival times are approximate (derived from computer simulation). Actual flood conditions may vary. Inundation mapping is to be used as approximate guidance only.

Depths are measured in reference to ground surface adjacent to building (not above first floor).

ATTACHMENT B

National Center for Computational Hydroscience and Engineering (NCCHE)

The University of Mississippi

FEMA

DSS-WISE™ Lite Flood Simulation Report

Storm Day (1146.0) Dam Breach (Froehlic
h Partial)

Williams Dam

NAXXXXX

February 18, 2022

Contact Information:

DSS-WISE™ Lite modeling questions: admin@dsswiseweb.ncche.olemiss.edu

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1.0 Overview

The Decision Support System for Water Infrastructure Security (DSS-WISE™) is an integrated software package combining 2D numerical flood modeling capabilities with a series of GIS-based decision support tools. It was developed by the National Center for Computational Hydroscience and Engineering (NCCHE) at the University of Mississippi and was initiated by the US Department of Homeland Security (DHS) Science and Technology Directorate through the Southeast Region Research Initiative (SERRI) Program.

A simplified, and fully automated, version of the DSS-WISE™ software suite (DSS-WISE™ Lite Ver 1.0) was developed on behalf of the US Army Corps of Engineers (USACE) Critical Infrastructure Protection and Resilience (CIPR) Program and the DHS Office of Infrastructure Protection. This simplified dam break flood modeling capability was available to interested parties through the Dams Sector Analysis Tool (DSAT) secure web portal until November 2014. An updated version with more features was developed on behalf of Federal Emergency Management (FEMA) and is available at dsswiseweb.ncche.olemiss.edu.

The DSS-WISE™ Lite software suite, running on NCCHE servers, automatically processes input files for dam-break modeling scenarios submitted by an user. DSS-WISE™ Lite further simplifies simulations by making several general overarching assumptions in an effort to streamline data preparation and computations.

The results produced by this simplified dam-break flood simulation tool represent a rough approximation. They are not intended to replace more detailed flood inundation modeling and mapping products or capabilities developed by hydraulic and hydrologic engineers and GIS professionals.

The user is, therefore, warned that professional engineering judgment should be used in the interpolation of the results generated by this simplified and automated dam-break flood analysis.

To learn more about DSS-WISE™ and DSS-WISE™ Lite visit us at:
`https://dsswiseweb.ncche.olemiss.edu`

Disclaimer

Elevation Datum

All reported elevations use the North American Vertical Datum of 1988 (NAVD 88).

2.0 Modeling Parameters and Conditions

2.1 Project Information

Project Name:	Williams Dam
Scenario Name:	Storm Day (1146.0) Dam Breach (Froehlic h Partial)
NIDID:	NAXXXXX
Scenario Description:	Storm Day (1146.0) Dam Breach Froehlic h Partial Breach HEC-HMS Hydrograph 162 4 cfs Baseflow 40 Bottom Breach Width 0 .2 hr Failure Time 8712.4 cfs Peak Disc harge 7.5 sq. mi. 2 days 15 ft x 15 ft cell size
User e-mail:	andrew.sampsell@vermont.gov

2.2 Simulation Parameters

Domain buffer distance (miles):	7.5
Simulation cell size requested (ft):	15.0
Simulation duration requested (days):	2

2.3 Impounding Structure(s) Characteristics

Number of Structures: 1

Structure Name:	Williams Dam
Structure Type:	Embankment
Hydraulic Height (ft):	17.0
Crest Elevation (ft):	1150.0
Length (ft):	97.0982233099

2.4 Bridge(s) to be Removed

Number of Bridges: 0

2.5 User-Specified Breach Hydrograph

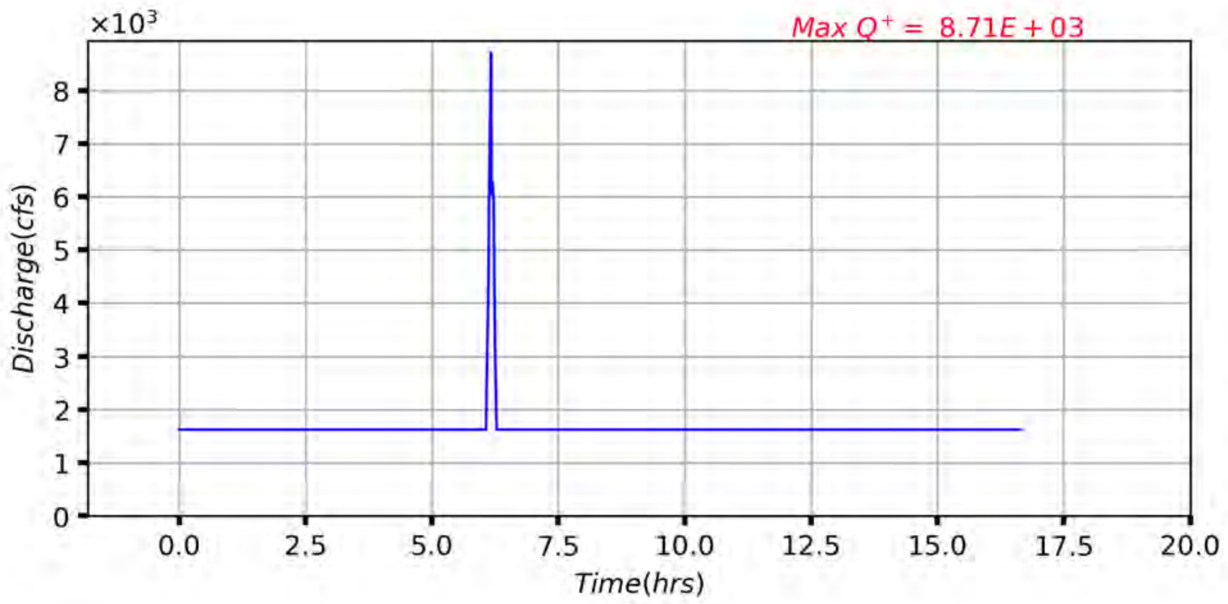

Figure 1. Breach inflow hydrograph for: Williams Dam.

2.6 Reservoir Characteristics

Number of Reservoirs: 1

Reservoir Name:	Williams Dam Reservoir
Selected Reservoir Point (Latitude/Longitude):	43.2266717542/-72.8063386331
Pool Elevation @ Max Storage (ft):	1146.0
Maximum Storage Volume (ac-ft):	97.1
Pool Elevation @ Normal Storage (ft):	1143.0
Normal Storage Volume (ac-ft):	42.43
Pool Elevation @ Failure (ft):	1146.0
Failure Storage Volume (ac-ft):	97.1

2.7 Failure Conditions

Structure ID:	1
Structure Name:	Williams Dam
Structure Type:	Embankment
Failure Mode:	Partial Dam Breach
Breach Width (ft):	40.0
Breach Location (Latitude/Longitude):	43.226506097/-72.8072398148

3.0 Automated Data Preparation and Job Flow Summary

3.1 Job Flow Summary

1. Prepare Digital Elevation Model (DEM) and Land Use/Land Cover (LULC) tiles for the Area of Interest (AOI) based on requested cellsize and maximum downstream distance.
2. Burn U.S. Army Corps of Engineers (USACE) levee lines into DEM for the AOI.
3. Assign Manning's coefficients based on LULC classifications.
4. Validate user provided simulation input parameters.
5. Remove user identified bridges from the DEM.
6. Estimate reservoir bathymetry.
7. Extend impounding structures if the specified reservoir level cannot be contained.
8. Fill reservoir to specified failure elevation.
9. Prepare boundary condition and all input data for simulation.

3.2 Reservoir Bathymetry and Filling

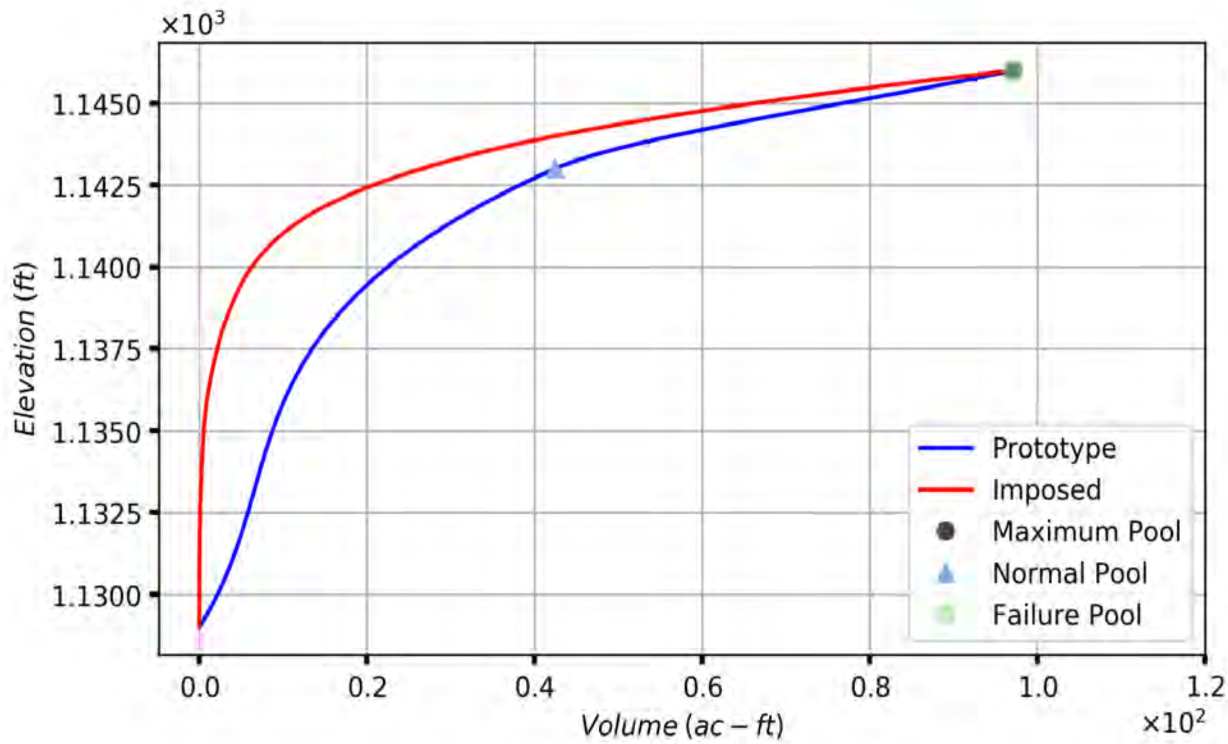

Figure 2. Stage-Volume Curve for Reservoir: Williams Dam Reservoir.

Prototype: Theoretical cubic Hermite spline curve generated from user-provided reservoir elevation and volume information.
Imposed: Measured from reservoir bathymetry after filling to the failure elevation.

The reservoir water surface was detected to be in the DEM, so bathymetry estimation was performed using the prototype stage-volume curve shown above.
User-given Storage Volume at Failure (ac-ft): 97.1
Imposed Storage Volume at Failure (ac-ft): 97.1
After filling to the failure elevation, the imposed reservoir volume matched 100.0% of the prototype volume.

3.3 Data Sources

1. Digital Elevation Models

   Sources: USGS 2018 National Elevation Dataset, NOAA, DEM provided by group.

   Resolutions: 2, 1, 1/3, 1/9, 0.15 arc-seconds, 1 meter, and 10 feet based on availability

   Vertical Datum: NAVD88

   Horizontal Datum: NAD83

2. National Land Use/Land Cover Data

   Source: USGS 2016 National Land Cover Database

   Resolution: 30 m

3. National Levee Database

   Source: USACE

3.4 Digital Elevation Model

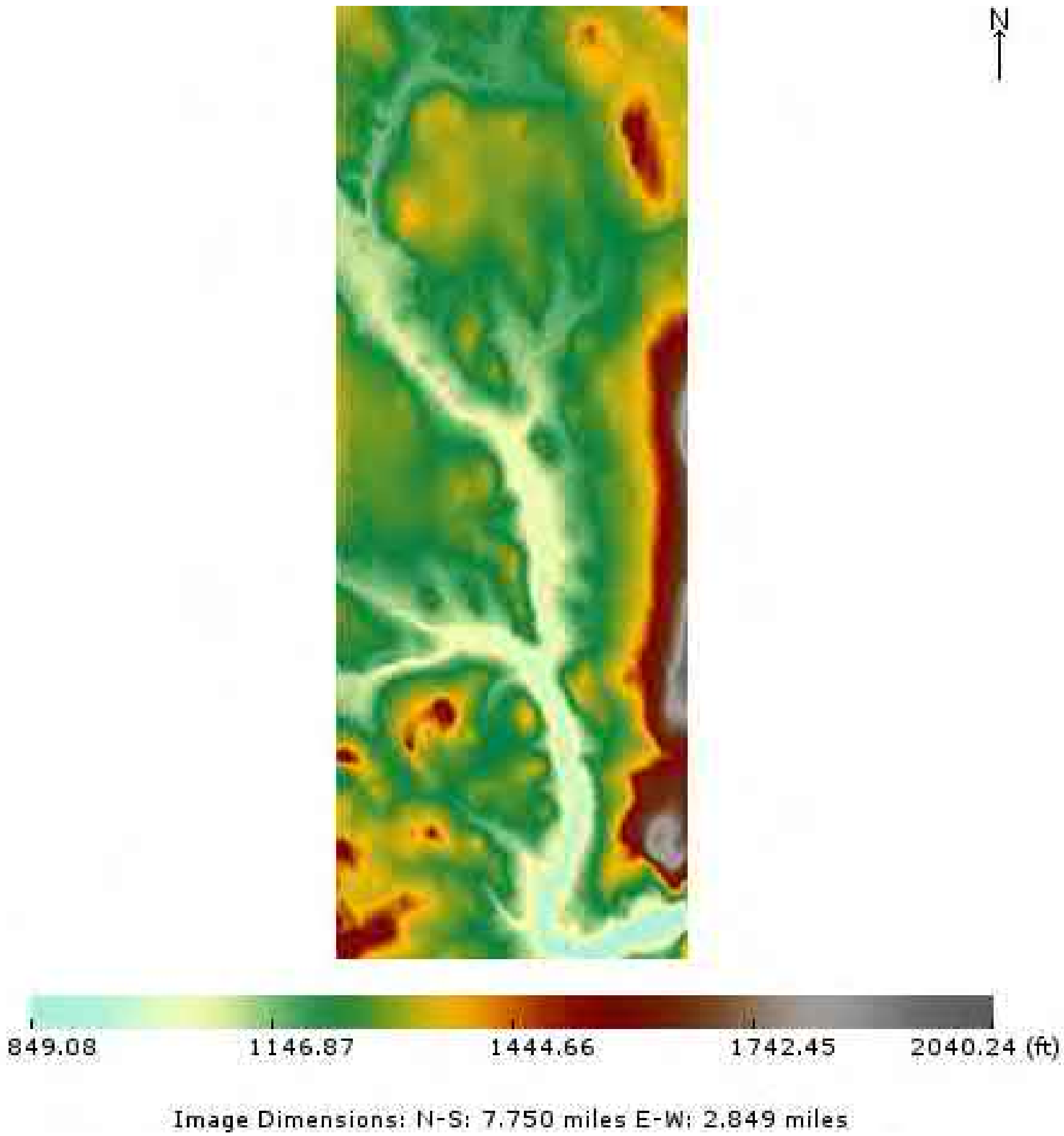

Figure 3. Map of Digital Elevation Model with Levees for AOI.

3.5 Reservoir Boundary and Breaching Structure

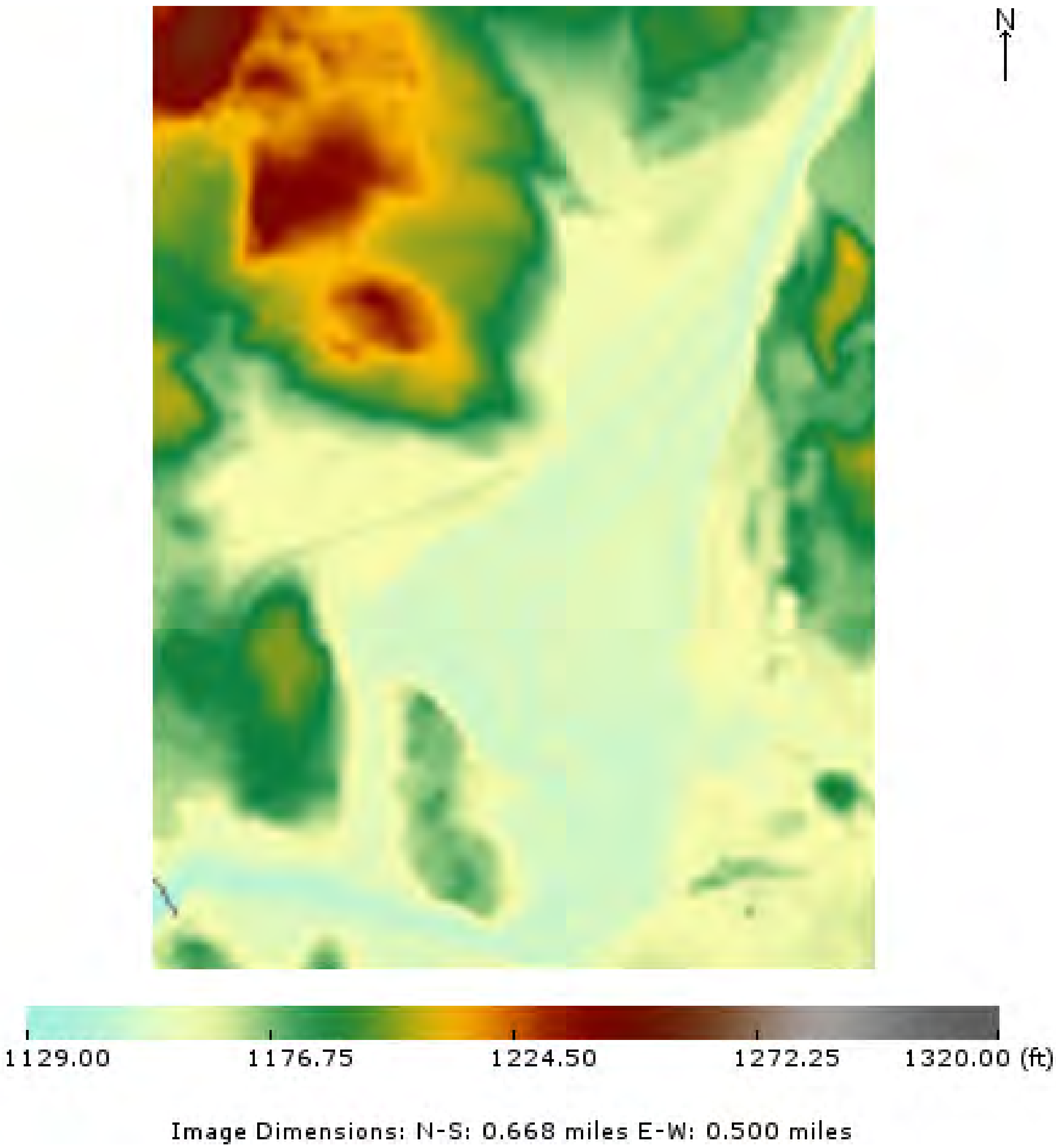

Figure 4. Map of Reservoir Boundary and Breached Structure.

3.6 Reservoir Initial Depth Profile

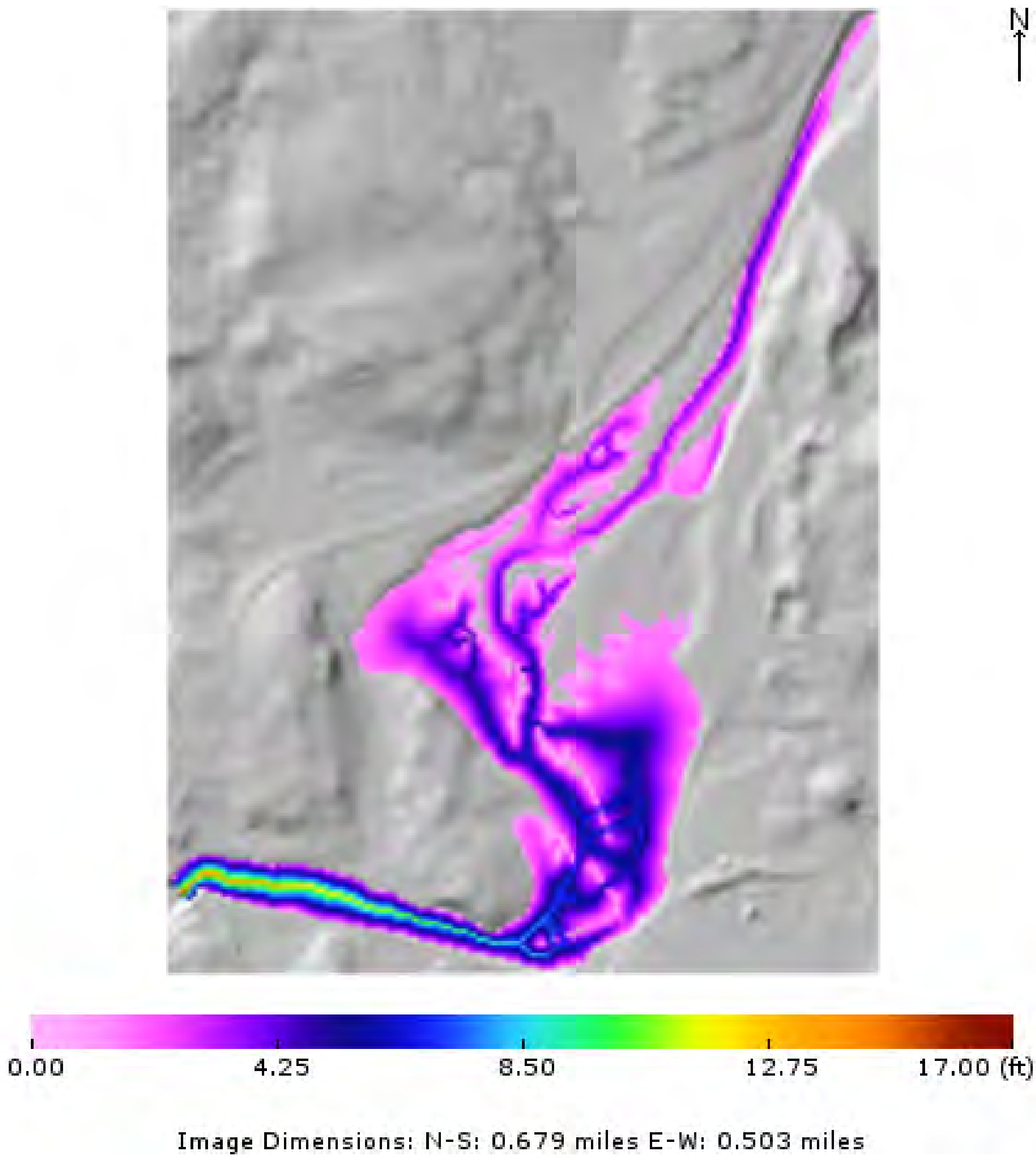

Figure 5. Map of Initial Depths in Reservoir at Failure Conditions.

3.7 Land Use/Land Cover

Figure 6. Map of Land Use for AOI.

4.0 Simulation Results

4.1 Simulation Summary

Simulation Request Received:	11:08 AM CST (02/18/2022)
Simulation Start Time:	11:09 AM CST (02/18/2022)
Simulation End Time:	11:17 AM CST (02/18/2022)
DEM resolution used for simulation (ft):	15.0
DEM resolution requested (ft):	15.0
Final distance reached downstream (miles):	7.2
Domain buffer distance (miles):	7.5
Elapsed simulation time after breach initiation (hrs):	23.2
Termination condition:	Water stopped spreading.

4.2 Land Use and Manning's Roughness Coefficient for Inundated Area

Land Use Description	% of Inundated Area	n-Value($m^{-1/3}s$)	Code	Color
Open Water	32.20	0.0330	11	
Evergreen Forest *	17.51	0.1000	42	
Woody Wetlands	16.24	0.1500	90	
Deciduous Forest *	8.22	0.1000	41	
Hay/Pasture	6.44	0.0350	81	
Barren Land	4.50	0.0113	31	
Developed, Low Density	3.81	0.0678	22	
Emergent Herbaceous Wetlands	2.74	0.1825	95	
Developed, Medium Density	2.42	0.0678	23	
Developed, Open Space	1.90	0.0404	21	
Mixed Forest *	1.59	0.1200	43	
Grassland/Herbaceous	1.04	0.0400	71	
Shrub/Scrub	0.91	0.0400	52	
Developed, High Density	0.31	0.0404	24	
Cultivated Crops	0.09	0.0700	82	
Unclassified	0.00	0.0350	0	
Perennial Snow/Ice	0.00	0.0100	12	
Dwarf Scrub *	0.00	0.0350	51	
Sedge/Herbaceous *	0.00	0.0350	72	
Lichens *	0.00	0.0350	73	
Moss *	0.00	0.0350	74	

Note: * indicates an n-value estimated by NCCHE. ** indicates an n-value given by the user. Other values are taken from literature.

4.3 Coverage and Sources of DEM Raster Datasets

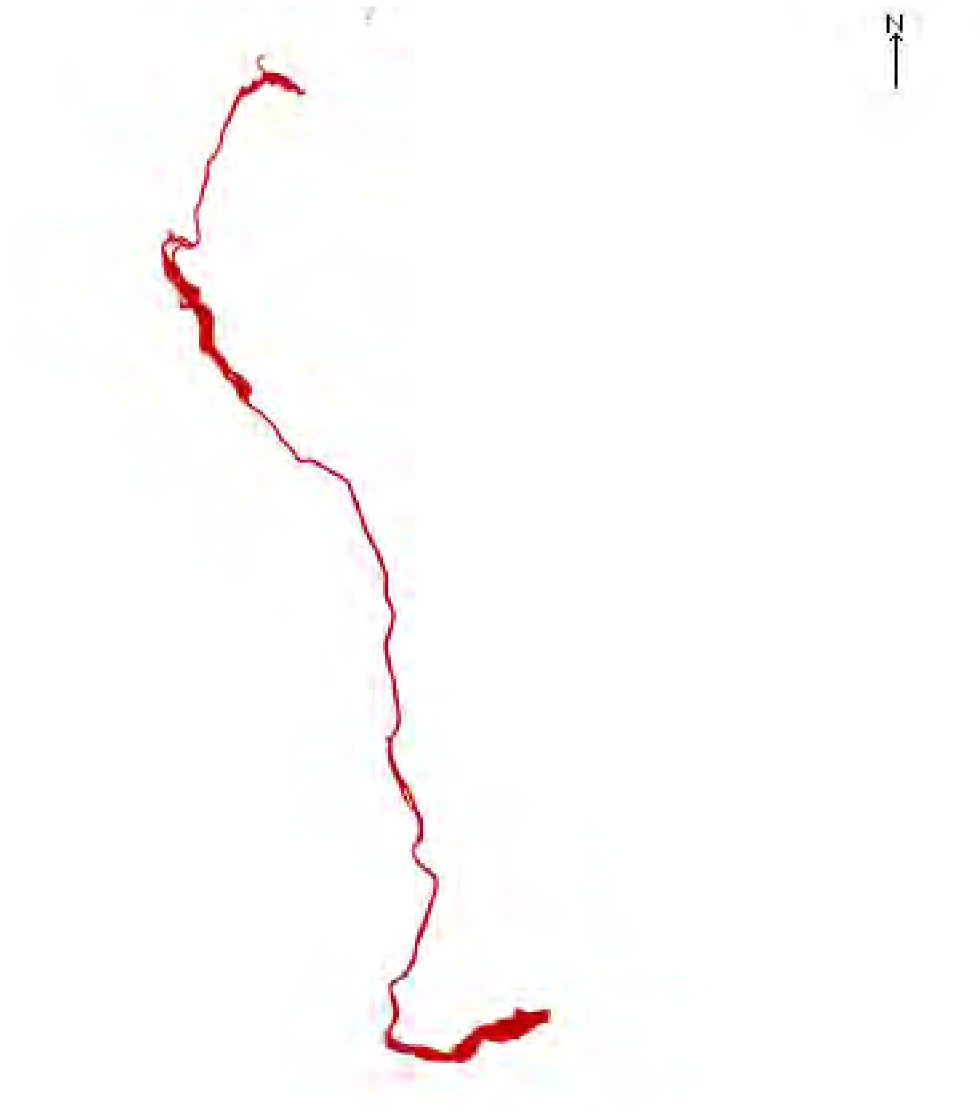

Figure 7. Coverage of DEM Raster Datasets in the Inundation Area.

DEM Source	Source Resolution	Source Dataset	Color
USGS	1 arc-second	usgs_1as	
USGS	1/3 arc-seconds	usgs_13as	
USGS	1 meter	usgs_utm_z18_1m	

Note: The DEM for this job was created from the source DEM raster datasets listed above. These DEM raster datasets were resampled and reprojected to the user defined cell size and UTM zone, respectively. Resampled and projected DEM raster datasets were then stacked in the order specific to the group under which this simulation was submitted.

4.4 Maximum Flood Depth

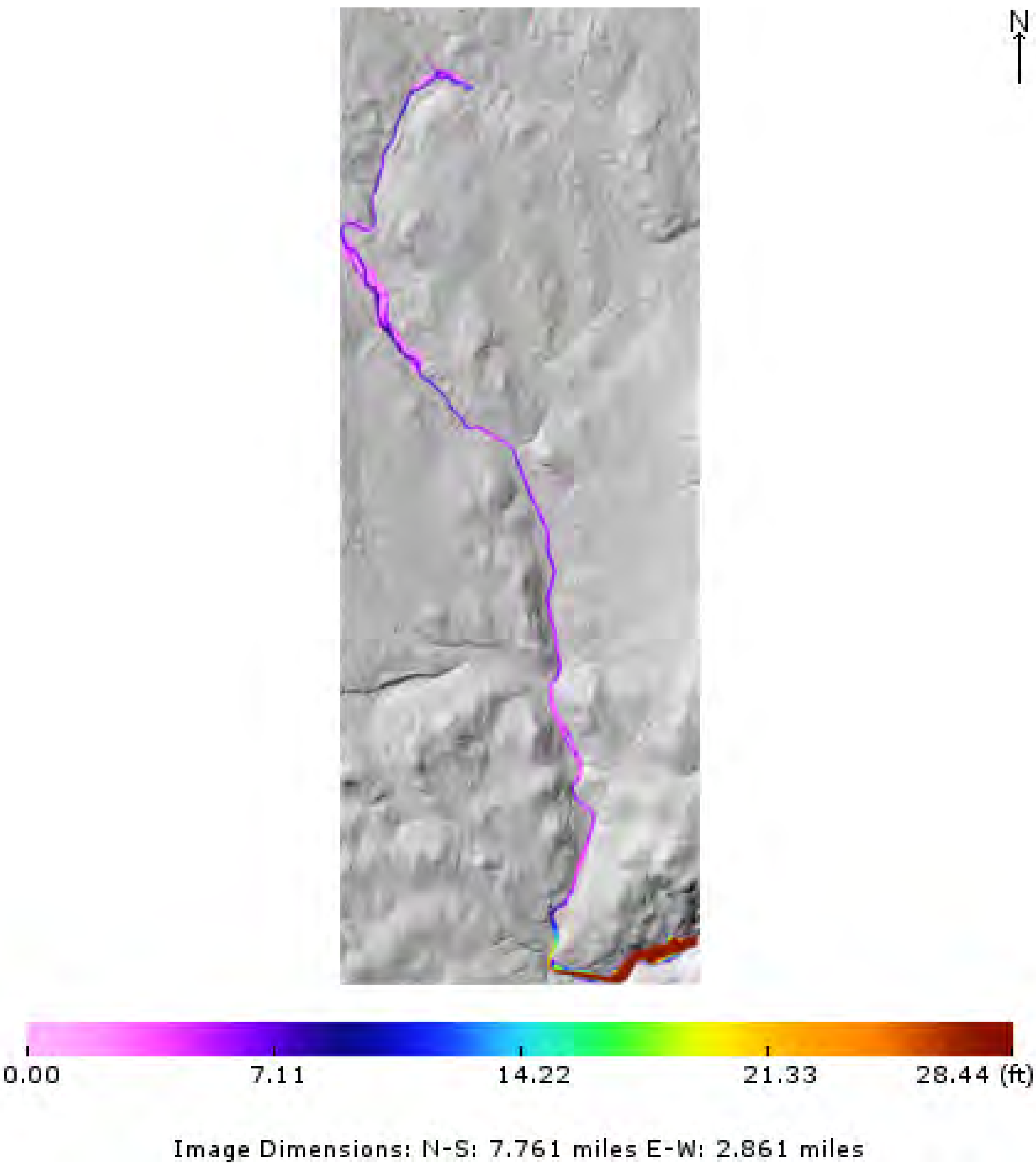

Figure 8. Maximum Flood Depth Map.

4.5 Flood Arrival Time

Flood arrival time is measured from the beginning of the simulation.

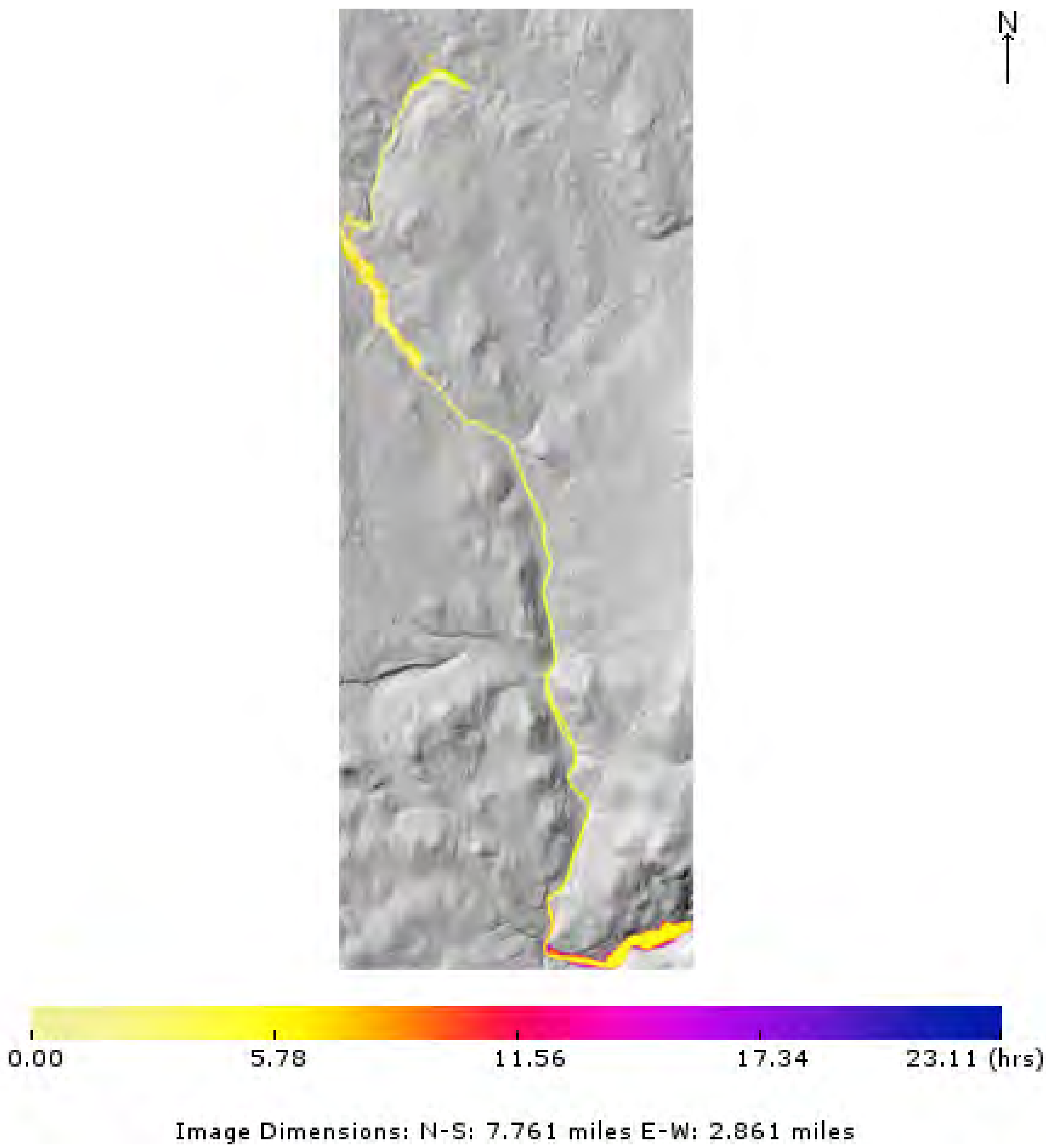

Figure 9. Flood Arrival Time Map.

4.6 Downloading Simulation Results

The simulation results can be accessed at the following web address:

`https://dsswiseweb.ncche.olemiss.edu/download`

Job ID: 44667

ATTACHMENT C

National Center for Computational Hydroscience and Engineering (NCCHE)

The University of Mississippi

DSS-WISE™ HCOM
HUMAN CONSEQUENCE REPORT

Williams Dam

Storm Day (1146.0) Dam Breach (Froehlich Partial)

NAXXXXX

February 18, 2022

DSS-WISE Lite Simulation ID: 44667

FOR OFFICIAL USE ONLY

Disclaimer

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EXECUTIVE SUMMARY

This document reports the human consequences assessment for the DSS-WISE Lite simulation ID: **44667**

INUNDATION EXTENT

Total inundated area (acres)(see figure 1): 323.02

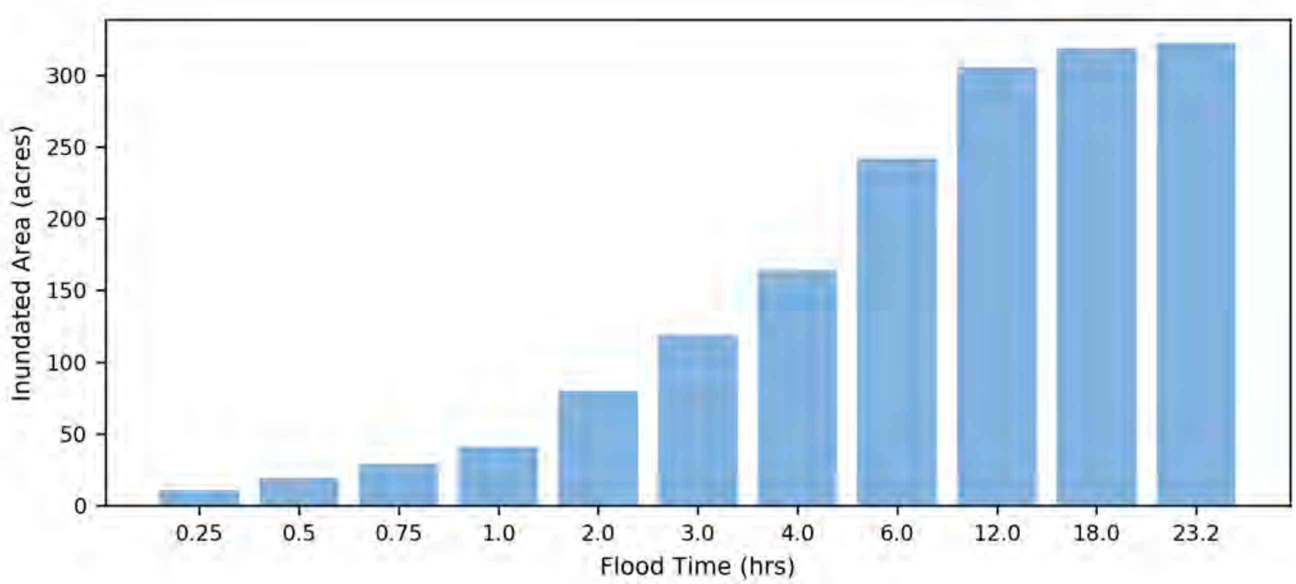

Figure 1. Evolution of total inundated area as a function of time.

ANALYSIS BASED ON CENSUS BLOCK DATA

Population in completely or partially inundated census blocks:	741
Housings in completely or partially inundated census blocks:	641
Number of states in inundated area:	1
Number of counties in inundated area:	1
Number of census blocks in inundated area:	44

ANALYSIS BASED ON GRIDDED LANDSCAN USA DATA

Total Nighttime PAR in inundated area (see figure 2):	7
Total Daytime PAR in inundated area (see figure 3):	47

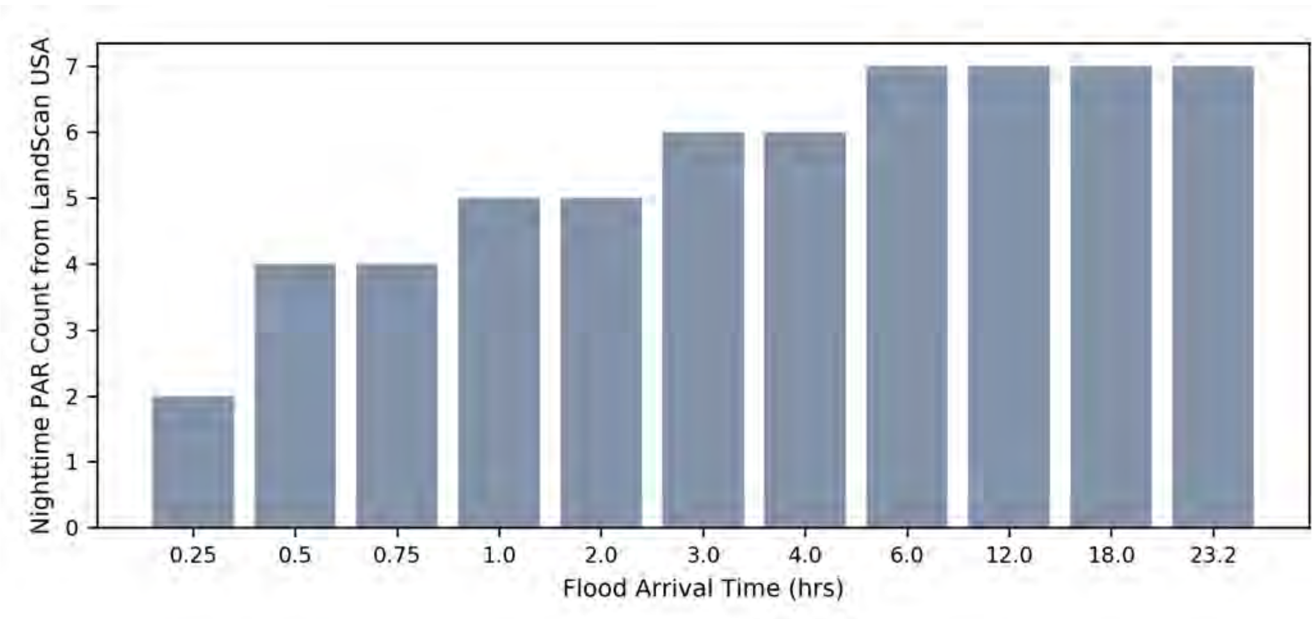

Figure 2. Evolution of nighttime PAR as a function of time.

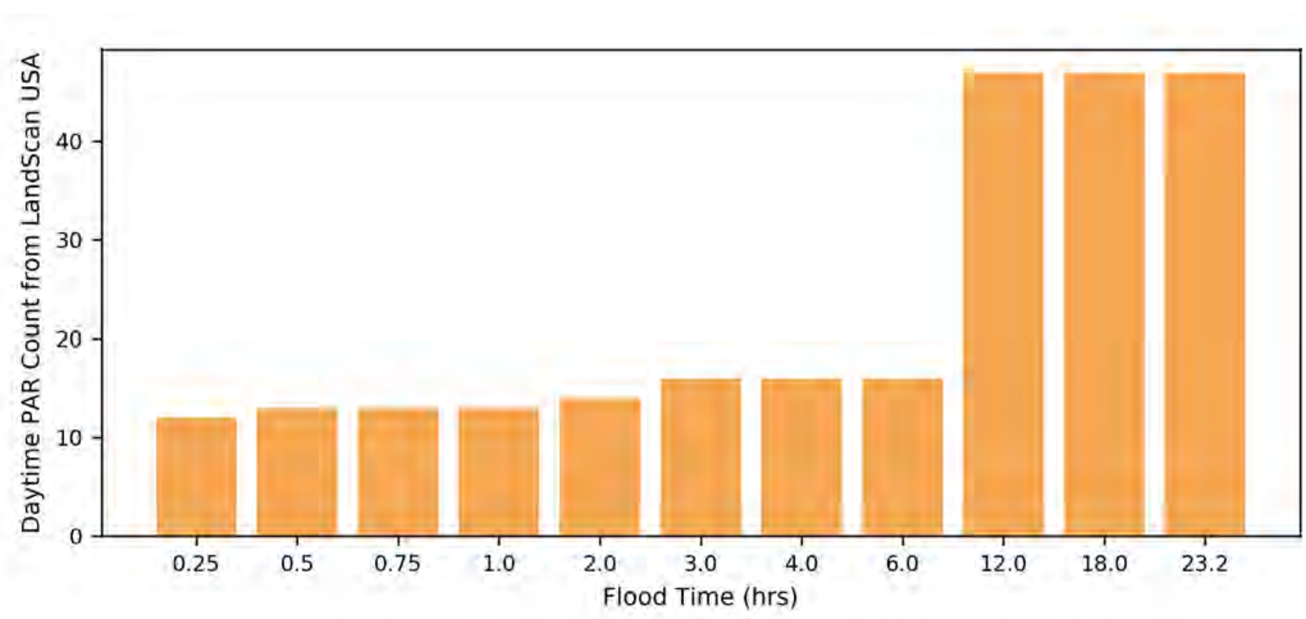

Figure 3. Evolution of daytime PAR as a function of time.

1.0 Overview

This report is produced DSS-WISE HCOM, which is part of the DSS-WISE Web system developed by the National Center for Computational Hydroscience and Engineering, at the University of Mississippi. Funding for DSS-WISE HCOM was provided by the U.S. Federal Emergency Management Agency (FEMA) through a contract with Argonne National Laboratory (ANL).

The results provided to the user by DSS-WISE HCOM include the following:

- the present report,
- a Microsoft Excel file containing data, results and plots, and
- a series of geospatial results files (in the form of polygon shapefiles).

These files can be used for further analysis and decision making for preparedness or during the response to an emergency. The files can also be used for hazard classification, risk prioritization preparing Emergency Actions Plans (EAPs).

DSS-WISE HCOM interfaces two-dimensional flood simulation results provided by DSS-WISE Lite with the population data provided by the U.S. Census Bureau and LandScan USA.

Please send any questions or suggestions to
admin@dsswiseweb.ncche.olemiss.edu

2.0 List of Abbreviations

ft	feet
hrs	hours
ft^2/s	Unit discharge, feet-squared per second
m^2/s	Unit discharge, meters squared per second
ft/s	feet per second
$ft.lb.$	foot-pounds
$m.kg.$	Meter-kilograms
D_{max}	Maximum depth
DV	Depth times velocity, unit discharge
DV_{max}	Maximum depth times velocity, maximum unit discharge
q_{max}	Maximum unit discharge, also called DV_{max}
DSS-WISE	Decision Support System for Water Infrastructural Security
DSS-WISE Web	Decision Support System for Water Infrastructural Security Web, the web-based system housing DSS-WISE Lite and other tools
DSS-WISE Lite	Decision Support System for Water Infrastructural Security Lite, the web-based version of DSS-WISE dam-break and flood modeling software
HCOM	Human Consequence Module
NCCHE	National Center for Computational Hydroscience and Engineering
PLFZ	Potentially Lethal Flood Zones
PAR	Population At Risk
EAP	Emergency Action Plan
NIDID	National Inventory of Dams (NID) Identifier
USCB	United States Census Bureau, or officially the Bureau of the Census
FEMA	Federal Emergency Management Agency
ANL	Argonne National Laboratory
ORNL	Oak Ridge National Laboratory
ESRI	Environmental Systems Research Institute
LSM	Life Safety Model

3.0 HCOM DATA SETS

3.1 DSS-WISE Lite Results Files

The human consequence analysis in this report are provided by DSS-WISE HCOM based on the raster results files for the following dam-break flood modeling simulation with DSS-WISE Lite:

DSS-WISE Lite simulation ID:	44667
Project Name:	Williams Dam
Scenario Name:	Storm Day (1146.0) Dam Breach (Froehlich Partial)
NIDID:	NAXXXXX
Scenario Description:	Storm Day (1146.0) Dam Breach Froehlich Partial Breach HEC-HMS Hydrograph 1624 cfs Baseflow 40 Bottom Breach Width 0.2 hr Failure Time 8712.4 cfs Peak Discharge 7.5 sq. mi. 2 days 15 ft x 15 ft cell size
Simulation distance requested ($miles$):	7.5
Simulation cell size (ft):	15.0
Simulation duration requested ($days$):	2.0

Table 1. DSS-WISE Lite results files used by DSS-WISE HCOM.

File Name	Type	Units	Description
44667_Hmax_ft_upto_final.tif	Raster	ft	Maximum flood depth
44667_Arrival_Time_hr_upto_final.tif	Raster	hrs	Flood Arrival Time
44667_Vmax_ftps_upto_final.tif	Raster	ft/s	Maximum flood velocity
44667_DVmax_ft2ps_upto_final.tif	Raster	ft^2/s	Magnitude of the maximum specific discharge
44667_DVmax_ft2ps_upto_final.tifArrivalTime	Raster	hrs	Arrival time of the maximum value of specific discharge

3.2 Population Data Sets Used by DSS-WISE HCOM

DSS-WISE HCOM uses two different sets of population data to estimate the Population at Risk (PAR) potentially affected by the flood:

1. 2010 Census Block data provided by the United States Census Bureau (USCB), which is federal government agency in charge of producing data about the people and economy of the U.S. A census block is the smallest geographic unit for which USCB collects data from all the houses in the unit (rather than a sample of houses). Census Blocks are bounded by visible features such as streets, roads, streams and nonvisible features such as property lines and limits of city, township, school district, and counties, etc. They are defined as polygons in a shapefile covering the entire territory of the U.S. including Puerto Rico and the Island areas. The attributes of the census block polygons include 2010 Census Housing Unit Count and 2010 Census Population Count. The latter should be considered as 2010 nighttime population data.

2. LandScan USA gridded population data developed and maintained by the Oak Ridge National Laboratory (ORNL) located in Oak Ridge, TN. LandScan USA (https://landscan.ornl.gov/) is a collection of gridded nighttime and daytime population datasets developed by the Oak Ridge National Laboratory (ORNL), Department of Energy. These gridded population datasets are available as raster files with a resolution of 3 arc-second ($90m$ or $295.28ft.$). They were developed by combining satellite remote sensing data, geospatial infrastructure datasets, and demographic data from USCB. Researchers at ORNL used "Intelligent" dasymetric modeling method to assign the population counts to the grid cells (Dobson et al. 2000 and Bhaduri et al. 2007) by defining a habitability index and by maintaining the total count of cells in a census block to be equal to the total population of the census block. The LandScan USA datasets used in this report are projections for 2016 (McKee et al. 2014). Daytime data is generated using specially developed techniques for population dynamics (Bhaduri 2007).

Detailed explanations on the methodologies used by DSS-WISE HCOM are provided in the technical manual, which can be downloaded from documentation page of the DSS-WISE Web website.

4.0 FLOOD HAZARD MAPPING

Flood-hazard mapping consists of partitioning the inundation extent into zones of predefined potential danger classes for humans. The resulting map is an ESRI shapefile of polygon type. The polygons correspond to different levels of potential danger for humans caught outdoors and indoors.

The potential danger classes are identified based on the ranges of the value of the maximum specific discharge, DV_{max}. The ranges of $q_{max} \equiv DV_{max}$ values are different for persons caught outdoors or indoors.

4.1 Potential Flood Hazard for Humans Caught Outdoors

For humans caught outdoors, the ranges of DV_{max} corresponding to five potential hazard (or danger) levels identified by different color codes are summarized in Table 2, which is adapted from Cox et al. (2010). The potential hazard levels are:

1. “Very Low Hazard: Shallow flow or deep standing water”;
2. “Low Hazard: Dangerous to children”;
3. “Moderate Hazard: Dangerous to some adults”;
4. “Significant Hazard: Dangerous to most adults”; and
5. “Extreme Hazard: Dangerous to all”.

The three rightmost columns of Table 2 correspond to the interpretation of five potential hazard levels by Cox et al. (2010) for three population categories defined by an index value corresponding to the product of height (H) and mass (M) of the individual as listed at the bottom of Table 2.

1. “Infants and small Children”,
2. “Children”, and
3. “Adults”;

The five polygons corresponding to the five potential flood hazard levels for people caught outdoors as listed in Table 2 are provided as an ESRI shapefile of polygon type.

Cox et al. (2010) notes that the limits of DV_{max} in Table 2 correspond loosely to the loss of stability of different population categories. However, it is important to note that the ranges of DV_{max} given in Table 2 should not be considered as strict limits. Various other factors may influence the stability of individuals caught outdoors by the flood, such as:

- Bottom conditions (uneven surface, slippery surface, visible or invisible obstacles);
- Flow conditions (floating debris, low temperature, poor visibility, unsteady flow and flow aeration);
- Human subject (standing or moving, experience and training, clothing and footwear, physical attributes, such as height, mass and muscular development, disabilities, and psychological factors); and
- Other factors (strong wind, poor lighting, feeling unsafe or complete loss of footing).

Table 2. Potential flood hazard levels for humans caught outdoors by the flood (adapted from Cox et al. 2010).

<table>
<tr><th colspan="4">DV_{max}</th><th rowspan="3">Potential Hazard Category</th><th colspan="3">Explanation</th></tr>
<tr><th colspan="2">m^2/s</th><th colspan="2">ft^2/s</th><th rowspan="2">Adults</th><th rowspan="2">Children</th><th rowspan="2">Infants, Small Children and Frail/Older Persons</th></tr>
<tr><th>from</th><th>to</th><th>from</th><th>to</th></tr>
<tr><td>0.0</td><td>0.4</td><td>0.0</td><td>4.3</td><td>HZ01
Very Low Hazard: Shallow flow or deep standing water</td><td rowspan="2">Low Hazard</td><td>Low Hazard</td><td rowspan="5">Extreme Hazard Dangerous to all Infants, small Children and Frail/Older Persons</td></tr>
<tr><td>0.4</td><td>0.6</td><td>4.3</td><td>6.5</td><td>HZ02
Low Hazard: Dangerous to Children</td><td rowspan="2">Significant Hazard; Dangerous to most Children</td></tr>
<tr><td>0.6</td><td>0.8[2]</td><td>6.5</td><td>8.6[2]</td><td>HZ03
Moderate Hazard: Dangerous to some adults</td><td>Moderate Hazard: Dangerous to some adults</td></tr>
<tr><td>0.8</td><td>1.2[3]</td><td>8.6</td><td>13[3]</td><td>HZ04
Significant Hazard: Dangerous to most adults</td><td>Significant Hazard: Dangerous to most adults</td><td rowspan="2">Extreme Hazard: Dangerous to all children</td></tr>
<tr><td>1.2[3]</td><td></td><td>13[3]</td><td></td><td>HZ05
Extreme Hazard: Dangerous to all</td><td>Extreme Hazard: Dangerous to all</td></tr>
<tr><td colspan="8">1) Small children, children and adult categories are defined based on $height(H) \times mass(M)$
Small children: $H \times M \leq 25l(m.kg.)$ $H \times M \leq 181(ft.lb.)$
Children: $25 < H \times M(m.kg.) \leq 50$ $181 < H \times M(m.kg.) \leq 362$
Adult: $50 < H \times M(m.kg.)$ $362 < H \times M(ft.lb.)$</td></tr>
<tr><td colspan="8">2) Recommended upper limit of tolerable working flow regime for trained safety workers or experience and well-equipped persons</td></tr>
<tr><td colspan="8">3) Above this value, the hazard is extreme according to majority of the past studies.</td></tr>
</table>

Results file package of DSS-WISE HCOM contains an ESRI shapefile of polygon type containing up to five polygons (see Table 6) corresponding to the five potential flood hazard levels for humans caught outdoors by the flood, which are listed in Table 2. For convenience, Map 09 of this report shows the inundation extent colored by the five potential flood hazard levels listed in Table 2.

4.2 Flood Hazard for Humans Caught Indoors

For people caught indoors by the flood, it is assumed that the potential danger is associated with the collapses of the building (see FEMA 2011, p.43). This implicitly assumes that the people indoors are in potential danger of loss of life if the building collapses due to inundation by floodwaters.

Table 3 list the DV_{max} values for the potential collapse of different types of buildings, which are taken from the technical report of the Life Safety Model (LSM) developed by British Columbia Hydro (BCH 2006).

Table 3. Potential flood hazard levels for humans caught indoors based on the BC Hydro LSM Building Stability Criteria.

DV_{max}		Color Code	Building Type
(m^2/s)	(ft^2/s)		
≥5	≥54		HZ06: Poorly constructed building
≥10	≥108		HZ07: Well-built timber building
≥15	≥161		HZ08: Well-built masonry building
≥20	≥215		HZ09: Concrete building
≥35	≥377		HZ10: Large concrete building

Results file package of DSS-WISE HCOM contains an ESRI shapefile of polygon containing up to five stacked polygons (see Table 6) corresponding to the five potential flood hazard levels for humans caught indoors by the flood, which are listed in Table 3. For convenience, Map 10 of this report shows the inundation extent colored by the five potential flood hazard levels listed in Table 3.

5.0 MAPPING POTENTIALLY LETHAL FLOOD ZONES (PLFZs) FOR CHILDREN AND ADULTS

The mapping of potentially lethal flood zones (PLFZs) for humans consists of partitioning the inundation extent into zones of predefined potential lethality classes for humans. The resulting map is an ESRI shapefile of polygon type for each category. The polygons correspond to different levels of potential lethality that are defined based on the maximum depth, D_{max}, and maximum specific discharge, DV_{max}. The PLFZs for different categories of people caught outdoors, cars, mobile homes and typical residential structures are listed in Table 4 (Feinberg, 2017).

Table 4. Definition of potentially lethal flood zones (PLFZs) for different categories (Feinberg, 2017).

Category	Color Code	D_{max} $(ft.)$		DV_{max} (ft^2/s)
Children caught outdoors (tent camping, fishing, hiking, etc.)		≥2	or	≥5.4
Adults caught outdoors (tent camping, fishing, hiking, etc.)		≥4	or	≥6.5
Motor vehicle (compact car) floating	None	≥1	or	≥4.3
Motor vehicle (compact car) sliding/toppling	None			≥5.4
Mobile homes	None	≥2	or	≥30
Typical residential structures	None	≥4	or	≥75

Results file package of DSS-WISE HCOM contains and ESRI shapefile of polygon type containing two stacked polygons corresponding to the first two categories in Table 4. These two polygons were extracted using the maximum flow depth and maximum specific discharge files provided in the results package of DSS-WISE Lite simulation (see Table 6). For convenience, Map 11 of this report shows the extents of these two PLFZ polygons.

The polygons for the remaining PLFZ zones can also be extracted from the D_{max} and DV_{max} raster files using a suitable GIS software.

6.0 POPULATION AT RISK (PAR) ANALYSIS

The population at risk (PAR) analysis aims to provide an estimate of the number of people that will be potentially affected by the propagation of the dam-break flood. DSS-WISE HCOM provides two different types of PAR analysis based on the two different population data sets that are available (see Section 3.2).

6.1 PAR Analysis Using Census Block Population Data

The results of the PAR analysis using 2010 census block population are given in two different forms:

- The list of the census blocks that are inundated (completely or partially) by the dam-break flood is provided in the "CensusBlock_Analysis" worksheet of the MS Excel file accompanying the present report.
- The polygons of the census blocks that are inundated (completely or partially) by the dam-break flood are provided in a shapefile accompanying the present report. The attributes of the census block polygons are the same as the data columns in the MS Excel file.

The polygons of census blocks included in the inundation extent (completely or partially) are provided as an ESRI shapefile (see Table 6) in the results package of DSS-WISE HCOM. The worksheet "CensusBlock_Analysis" lists all the census blocks and their attributes, which include various data extracted by DSS-WISE HCOM. The attributes of the census-block polygons are the same as the columns in the worksheet "CensusBlock_Analysis" of the MS Excel file accompanying the present report.

These attributes of the census blocks are listed and explained in Table 5. Map 06 in this report shows the census block polygon outlines overlaid on the flood extent.

Table 5. Attributes of the census block polygons in the shapefile and the corresponding columns in the worksheet "CensusBlock_Analysis" of the MS Excel file accompanying the present report.

ExcelFile		Shapefile	Unit	Description
Col	Title	Attributes		
A	State Name	STATE_NAME		Abbreviation of the state name
B	County Name	CNTY_NAME		County Name

C	State FIPS CODE	STATEFP10		2010 Census state FIPS code
D	County FIPS CODE	COUNTYFP10		2010 Census county FIPS code
E	Tract CODE	TRACTCE10		2010 Census tract code
F	Tabulation Block Number	BLOCKCE		2010 Census tabulation block number
G	Block ID Number	BLOCKID10		Census block identifier; A concatenation of 2010 Census state FIPS code, 2010 Census county FIPS code, 2010 Census tract code , and 2010 Census block number
H	Partial Block Indicator	PARTFLG		Y = partial block N = whole block
I	Total Number of Housing	HOUSING10	*Count*	2010 Census Housing Unit Count
J	Total Number of Population	POP10	*Count*	2010 Census Population Count
K	Total Area	AREATOT	*Acres*	Total area of the census block. This information is extracted from the geometry of the census block
L	Inundated Area	AREAINUND	*Acres*	Area of the census block inundated. This information is extracted by intersecting the inundation extent with the census block.
M	Percent Area Inundated	AINUND_PCT	%	This quantity is calculated in the MS Excel spreadsheet by the dividing the AREAINUND (column L) by the AREATOT (column K).

N	Flood Arrival Time (Avg)	FLDAT_AVG	hrs	This quantity is extracted from the arrival time raster. It corresponds to the average value of the arrival times of all computational cells within the extent of the census block.
O	Flood Arrival Time (Min)	FLDAT_MIN	hrs	This quantity is extracted from the arrival time raster. It corresponds to the minimum value of the arrival times of all computational cells within the extent of the census block.
P	Flood Arrival Time (Max)	FLDAT_MAX	hrs	This quantity is extracted from the arrival time raster. It corresponds to the maximum value of the arrival times of all computational cells within the extent of the census block.
Q	Flood Maximum Depth (Avg)	HMAX_AVG	ft	This quantity is extracted from the maximum flood depth raster. It corresponds to the average value of the maximum flood depths of all computational cells within the extent of the census block.
R	Flood Maximum Depth (Min)	HMAX_MIN	ft	This quantity is extracted from the maximum flood depth raster. It corresponds to the minimum value of the maximum flood depths of all computational cells within the extent of the census block.
S	Flood Maximum Depth (Max)	HMAX_MAX	ft	This quantity is extracted from the maximum flood depth raster. It corresponds to the maximum value of the maximum flood depth of all computational cells within the extent of the census block.

T	Flood Maximum DV Arrival Time (Avg)	DVMAXATAVG	hrs	This quantity is extracted from the arrival time of maximum specific discharge raster. It corresponds to the average value of the maximum specific discharge arrival times of all computational cells within the extent of the census block.
U	Flood Maximum DV Arrival Time (Min)	DVMAXATMIN	hrs	This quantity is extracted from the arrival time of maximum specific discharge raster. It corresponds to the minimum value of the maximum specific discharge arrival times of all the computational cells within the extent of the census block.
V	Flood Maximum DV Arrival Time (Max)	DVMAXATMAX	hrs	This quantity is extracted from the arrival time of maximum specific discharge raster. It corresponds to the maximum value of the maximum specific discharge arrival times of all the computational cells within the extent of the census block.
W	Flood Maximum DV (Avg)	DVMAX_AVG	ft^2/s	This quantity is extracted from the maximum specific dishcarge raster. It corresponds to the average value of the maximum specific discharge of all the computational cells within the extent of the census block.
X	Flood Maximum DV (Min)	DVMAX_MIN	ft^2/s	This quantity is extracted from the maximum specific dishcarge raster. It corresponds to the minimum value of the maximum specfic discharge of all the computational cells within the extent of the census block.

Y	Flood Maximum DV (Max)	DVMAX_MAX	ft^2/s	This quantity is extracted from the maximum specific dishcarge raster. It corresponds to the maximum value of the maximum specific discharge of all the computational cells within the extent of the census block.

6.2 PAR Analysis Using LandScan USA Gridded Population Data

The PAR analysis using LandScan USA 3 arc-second gridded population data provides three sets of tabular results classified in up to 17 flood times and 10 flood hazard categories based on DV_{max}:

- Tabular summary of inundation areas as a function of flood time is presented in the worksheet "InundatedArea" of the MS Excel file accompanying the present report. The inundation area values are presented as a stacked column plot in the same worksheet.
- Tabular summary of nighttime PAR counts as a function of flood time is presented in the worksheet "Nighttime_PAR" of the MS Excel fle accompanying the present report. The nighttime PAR counts are plotted as a stacked column plot in the same worksheet.
- Tabular summary of daytime PAR counts as a function of flood time is presented in the worksheet "Daytime_PAR" of the MS Excel fle accompanying the present report. The tabular data is also plotted as a stacked column plot.

The nighttime and daytime PAR counts were obtained from nighttime and daytime population densities, which were extracted from LandScan USA following the methologies described in the technical manual for DSS-WISE HCOM. Map 07 and Map 08 in this report show the nighttime and daytime population densities over the inundation area.

7.0 RESULTS FILES GENERATED BY DSS-WISE HCOM

All the results files generated by DSS-WISE HCOM are listed Table 6.

Table 6. List of results files generated by DSS-WISE HCOM.

No	Name	Type	Description
1	44667_HCOM_Final_Report.pdf	PDF	The present report.
2	44667_HCOM_Analysis.xlsx	Ms Excel	Ms Excel file accompanying this report. It contains four worksheets: 1. InundatedArea 2. Nighttime_PAR 3. Daytime_PAR 4. CensusBlock_Analysis
3	44667_HCOM_Census_Block_polygons.shp	ESRI Shapefile	This ESRI shapefile of polygon type contains the polygons of the census blocks completely or partially included in the inundation extent. The attributes of the polygons are the same as the columns in the worksheet "CensusBlock_Analysis". They are listed in Table 5.
4	44667_HCOM_Outdoor_Hazard_Categories_polygons.shp	ESRI Shapefile	This ESRI shapefile of polygon type contains up to five polygons corresponding to the five potential flood hazard levels for humans caught outdoors by the flood as listed in Table 2 (Section 4.1)
5	44667_HCOM_Indoor_Hazard_Categories_polygons.shp	ESRI Shapefile	This ESRI shapefile of polygon type contains up to five polygons corresponding to the five potential flood hazard levels for humans caught indoors by the flood as listed in Table 3 (Section 4.2)

6	44667_HCOM_PLFZ_polygons.shp	ESRI Shapefile	This ESRI shapefile of polygon type contains up to two stacked polygons corresponding to the PLFZ areas as listed in the first two rows of Table 4.
7	44667_HCOM_NT_PopDensity_persqmi_polygons.shp	ESRI Shapefile	This ESRI shapefile of polygons type contains polygon of nighttime population density per square mile extracted from LandScan USA data. This file should be treated as **FOUO**
8	44667_HCOM_DT_PopDensity_persqmi_polygons.shp	ESRI Shapefile	This ESRI shapefile of polygons type contains polygon of daytime population density per square mile extracted from LandScan USA data. This file should be treated as **FOUO**

8.0 REFERENCES

BCH (2006). Life Safety Model System v1.0, Guidelines, Procedures, Calibration and Support Manual. Technical Report Engineering Report E310, British Columbia Hydro (BCH).

Bhaduri, B., Bright, E., Coleman, Ph., Urban, M.L. (2007). LandScan USA: a high-resolution geospatial and temporal modeling approach for population distribution and dynamics. Geojournal 69:103-117. DOI 10.1007/s10708-007-9105-9

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Cox, R.J., Yee, M. and Ball, J.E. (2004). Safety of People in Flooded Streets and Floodways. 8th National Conference on Hydraulics in Water Engineering, Gold Coast. The Institution of Engineers, Australia.

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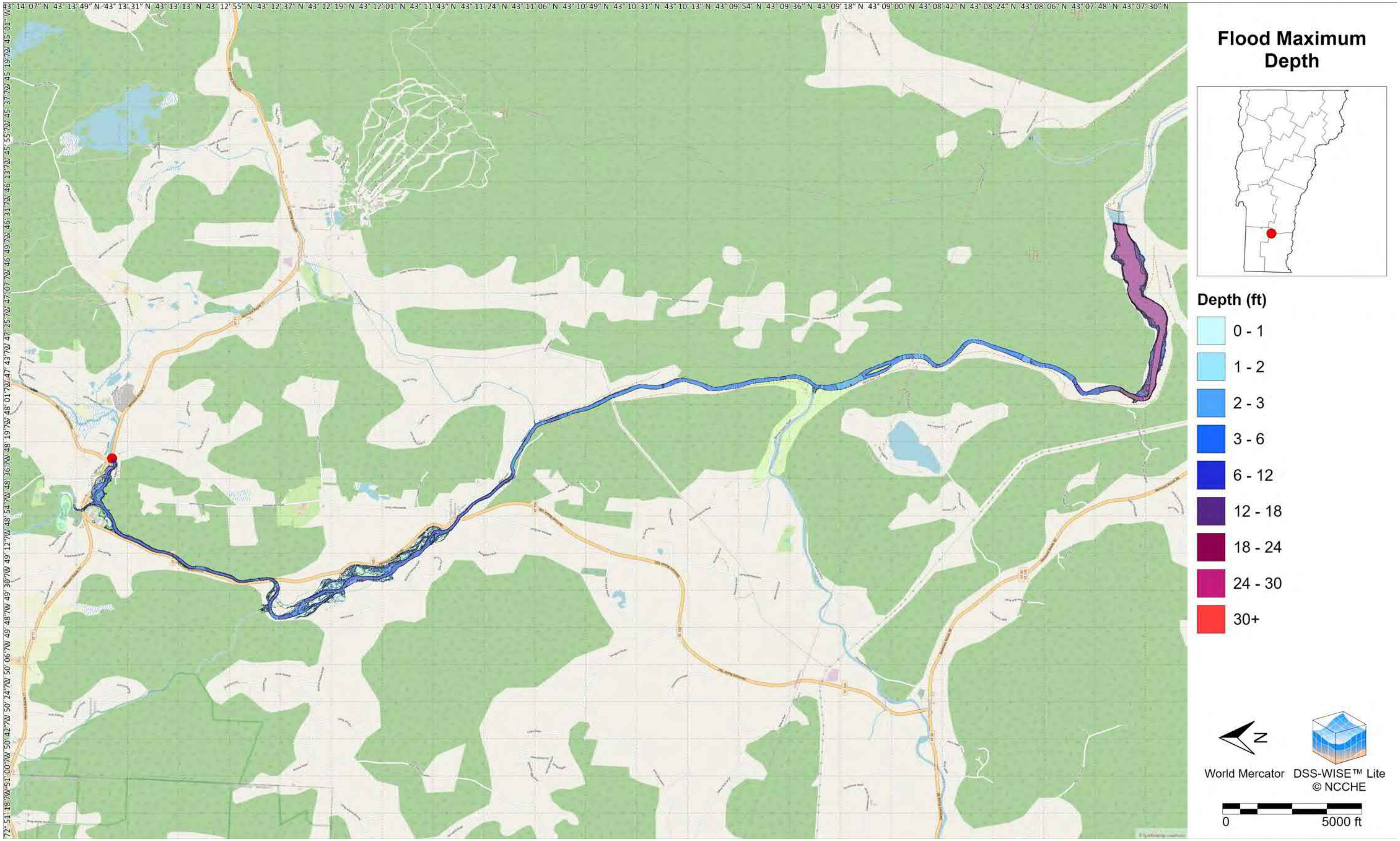
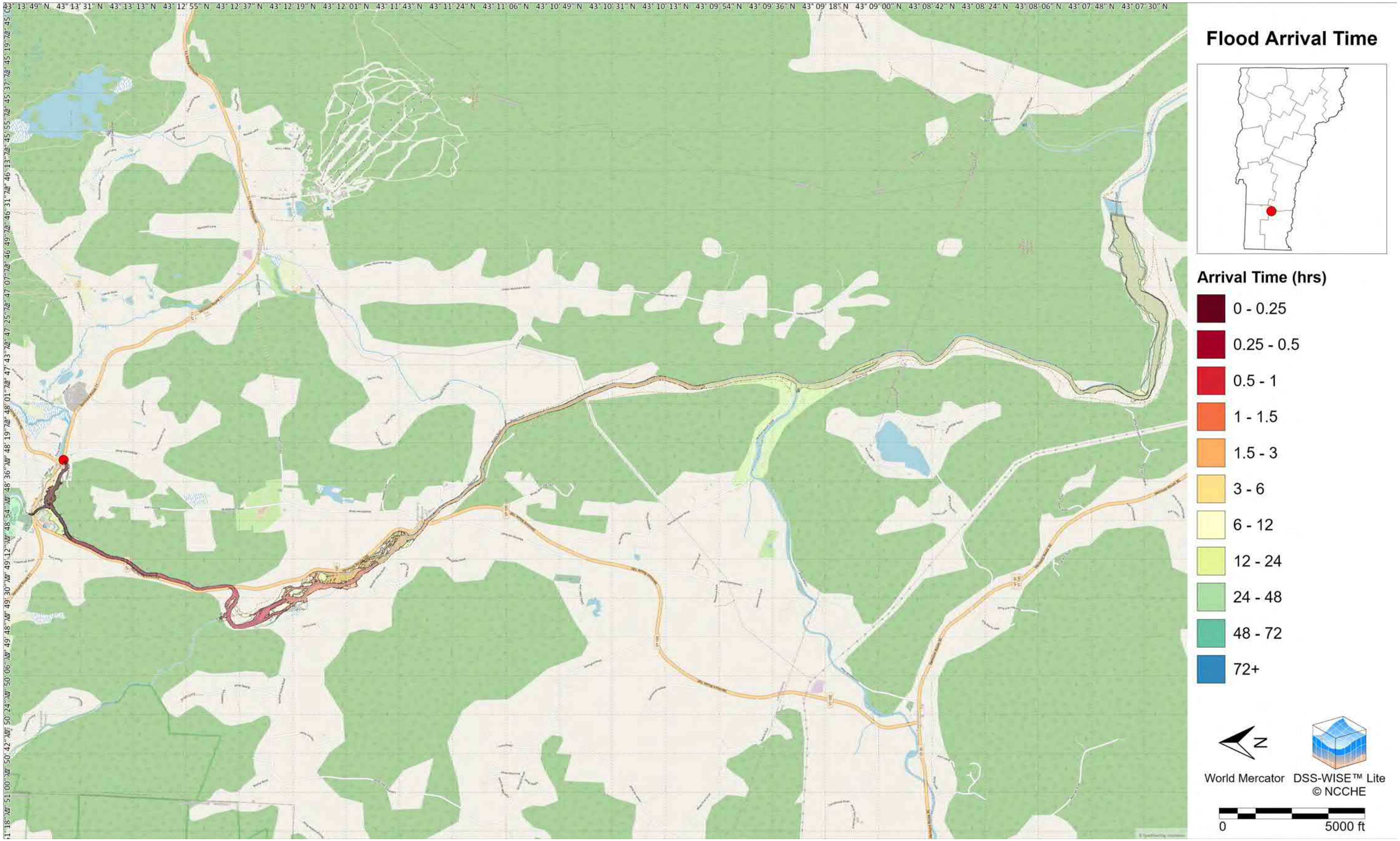
FEMA (2011). Estimating Loss of Life for Dam Failure Scenarios. Draft version.

McKee, J.J., Rose, A.N., Bright, E.A., Huynh, T., and Bhaduri, B.L. (2014). Locally adaptive, spatially explicit projection of US population for 2030 and 2050. PNAS, 112(5), 1344-1349. http://www.pnas.org/content/pnas/112/5/1344.full.pdf

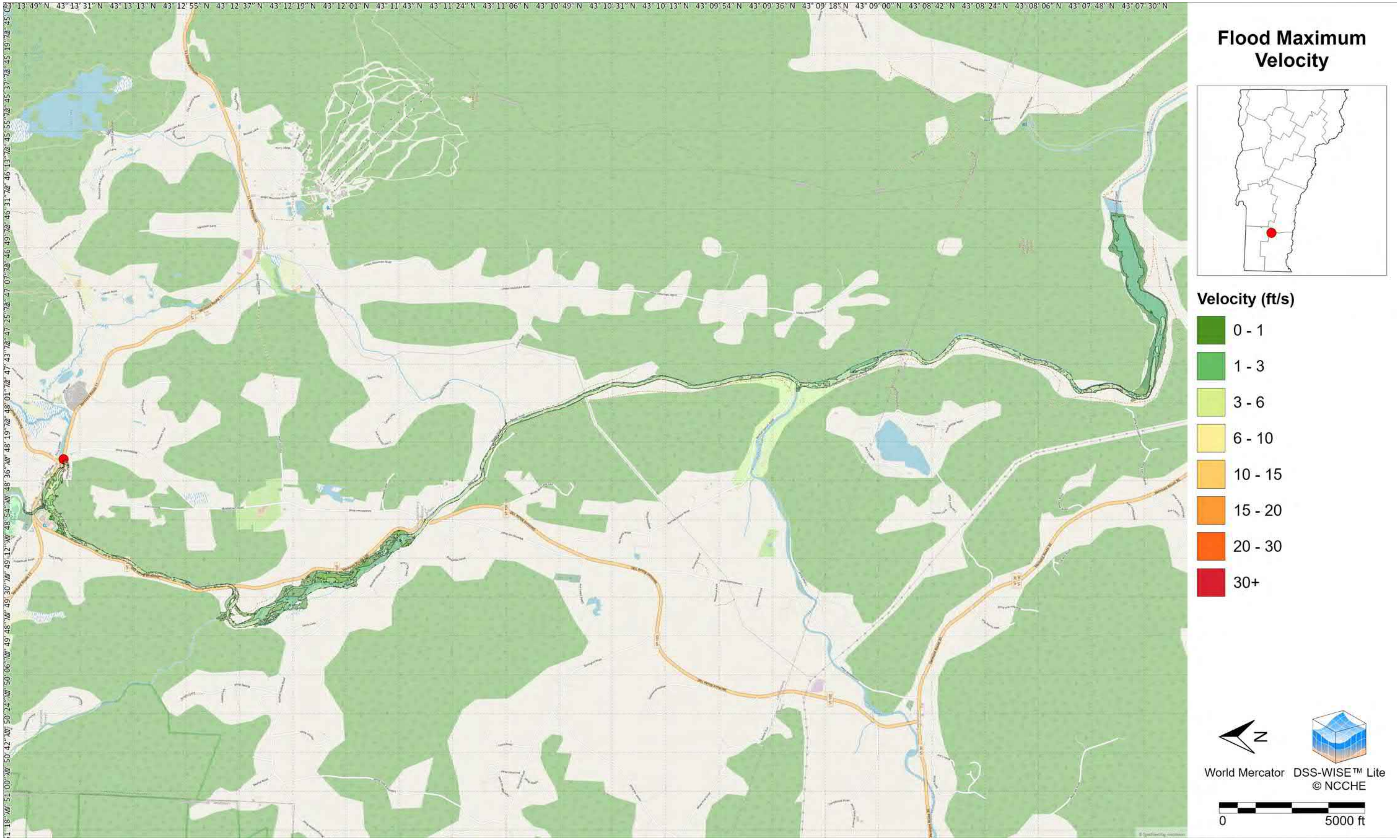
Map 01: Flood Maximum Depth



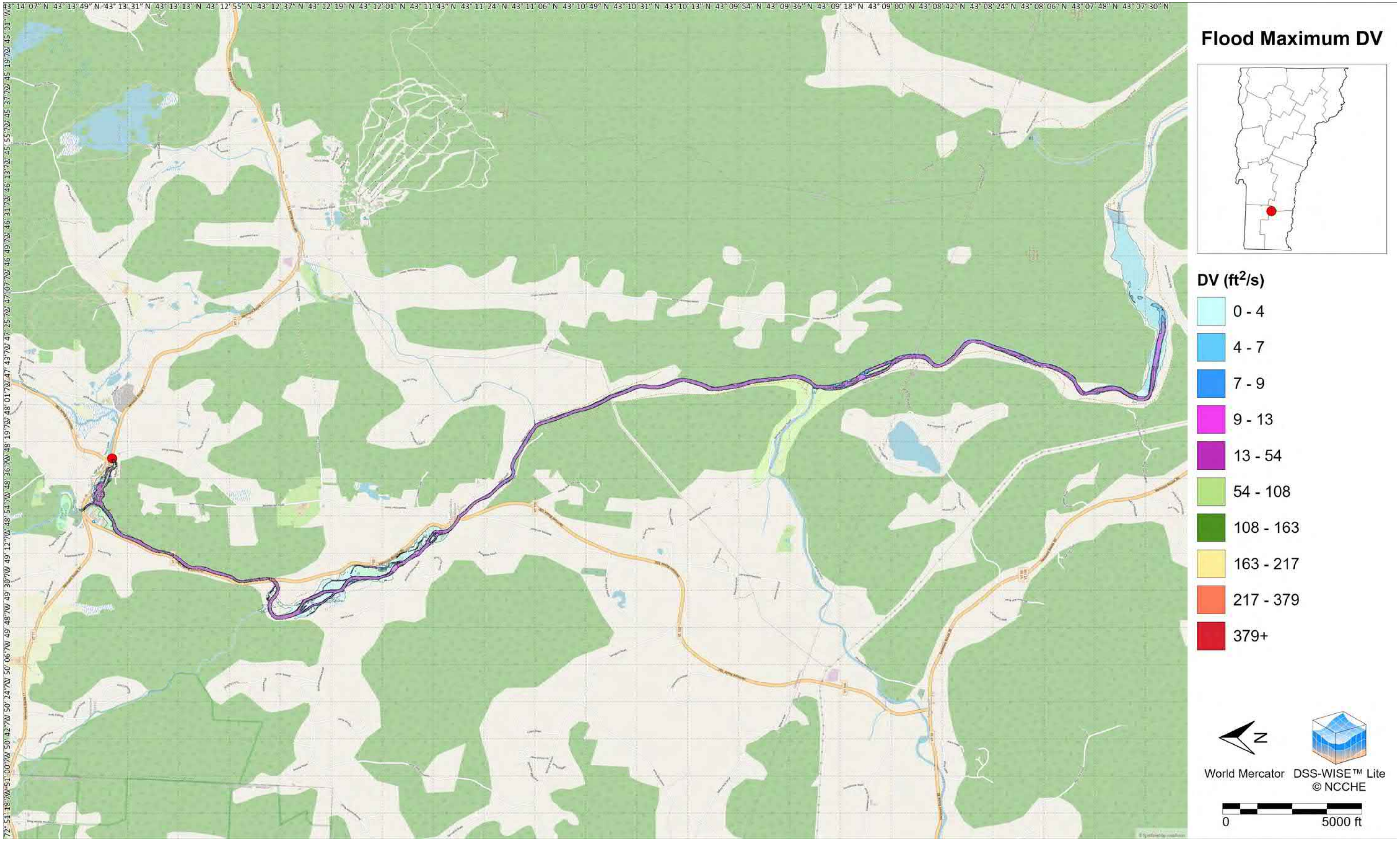
Map 02: Flood Arrival Time



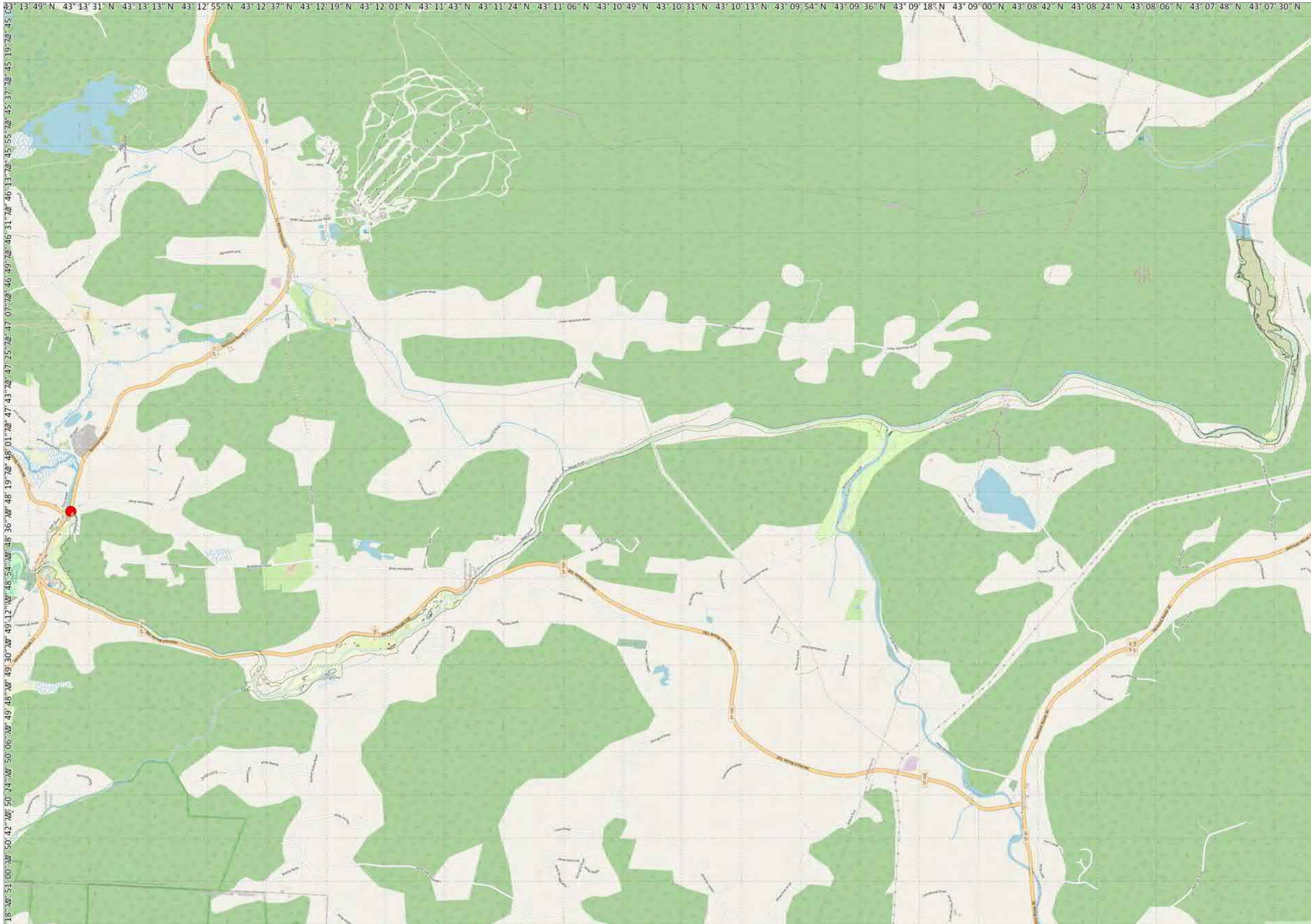
Map 03: Flood Maximum Velocity



Map 04: Flood Maximum DV



Map 05: Flood Maximum DV Arrival Time



Flood Maximum DV Arrival Time

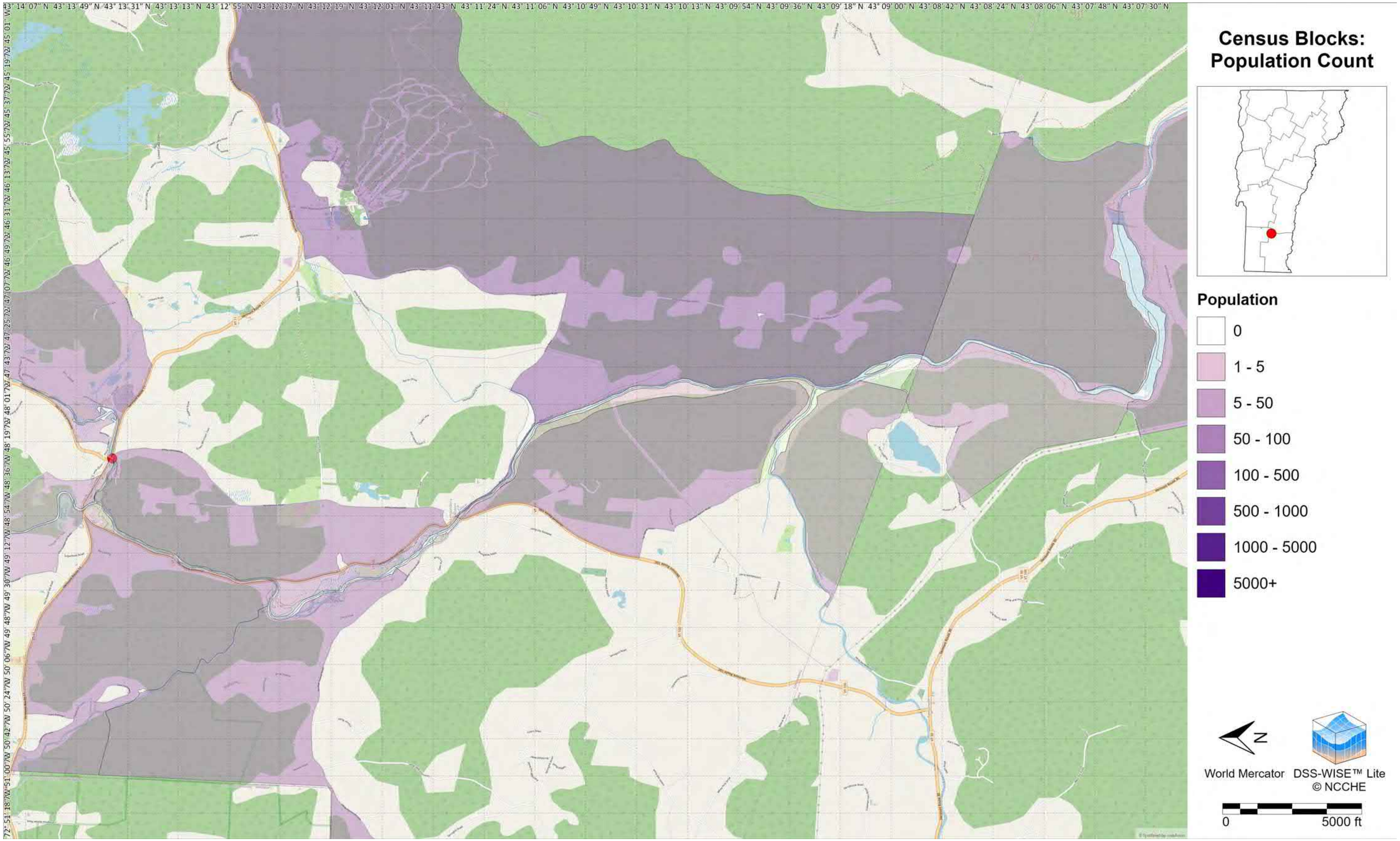
Arrival Time (hrs)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 3
- 3 - 6
- 6 - 12
- 12 - 24
- 24 - 48
- 48 - 72
- 72+

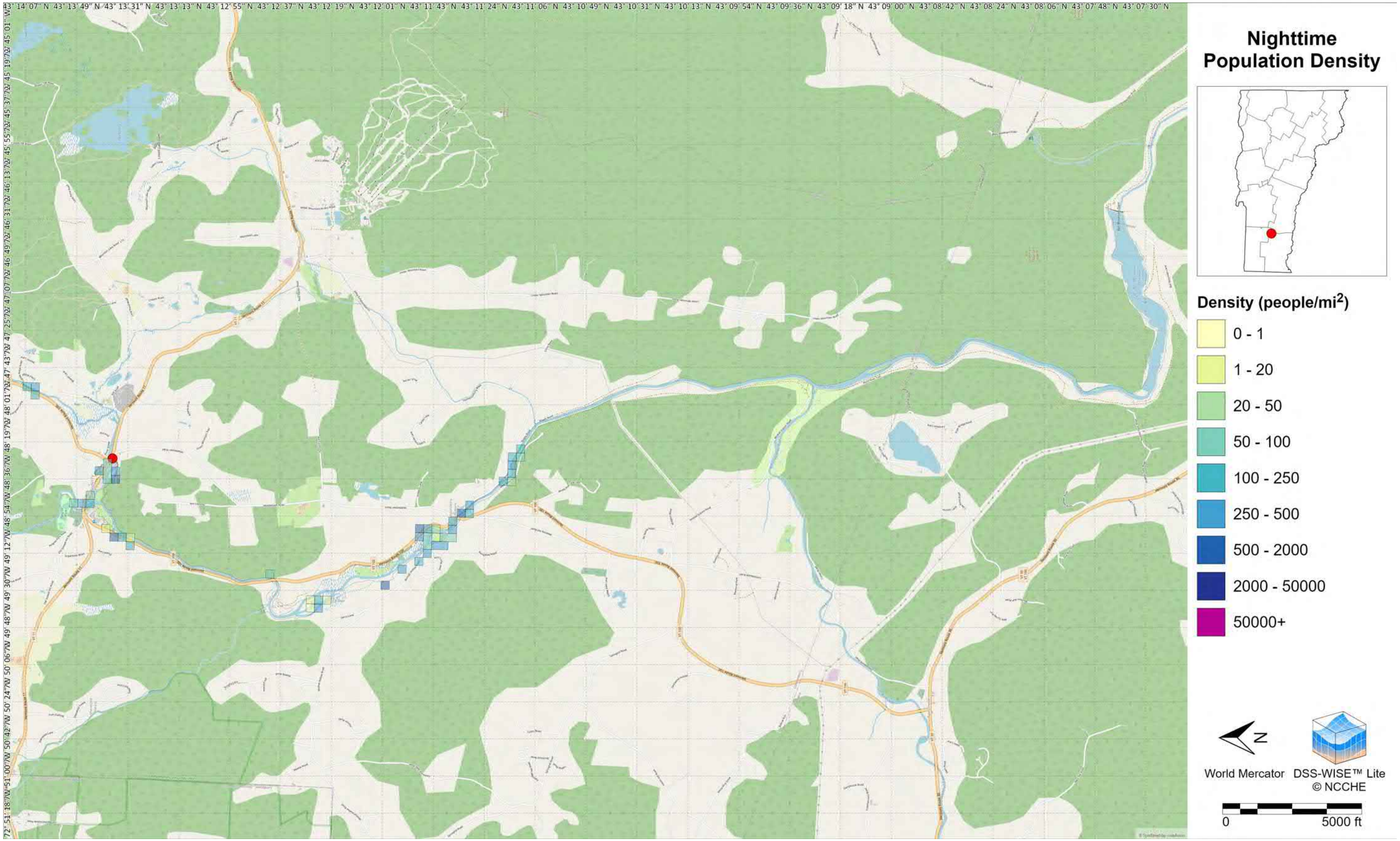
World Mercator

DSS-WISE™ Lite
© NCCHE

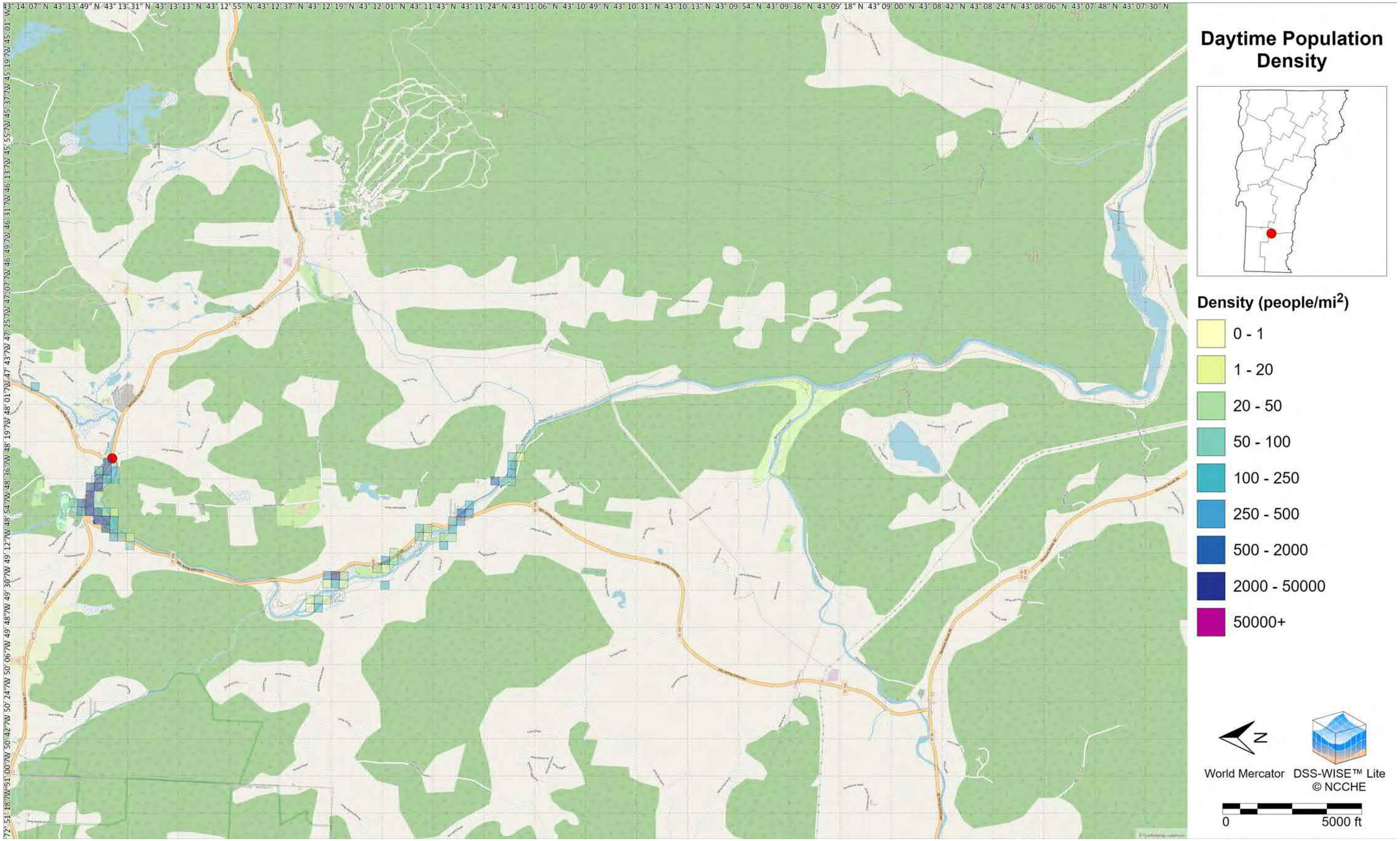
Map 06: Census Blocks: Population Count



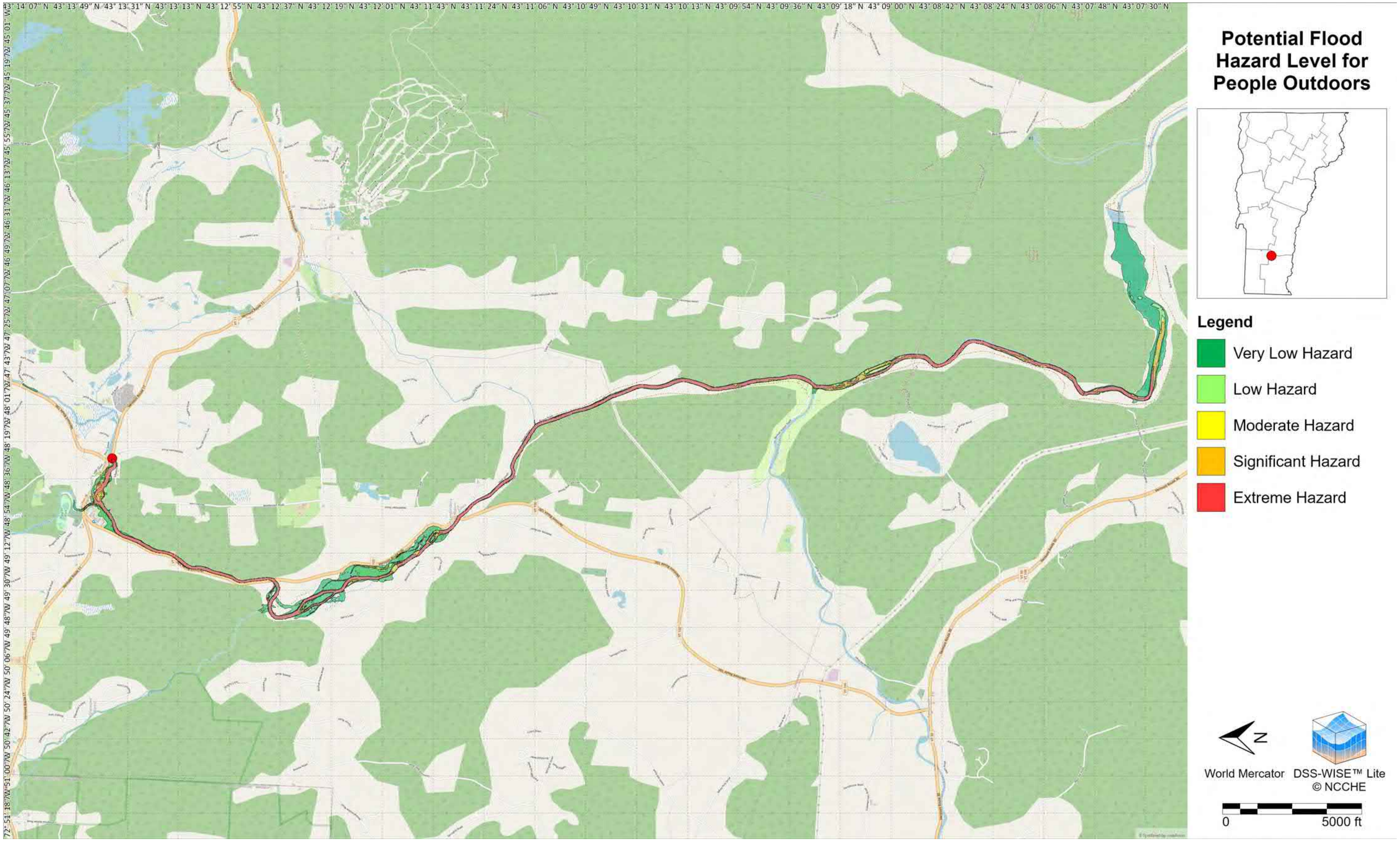
Map 07: Nighttime Population Density



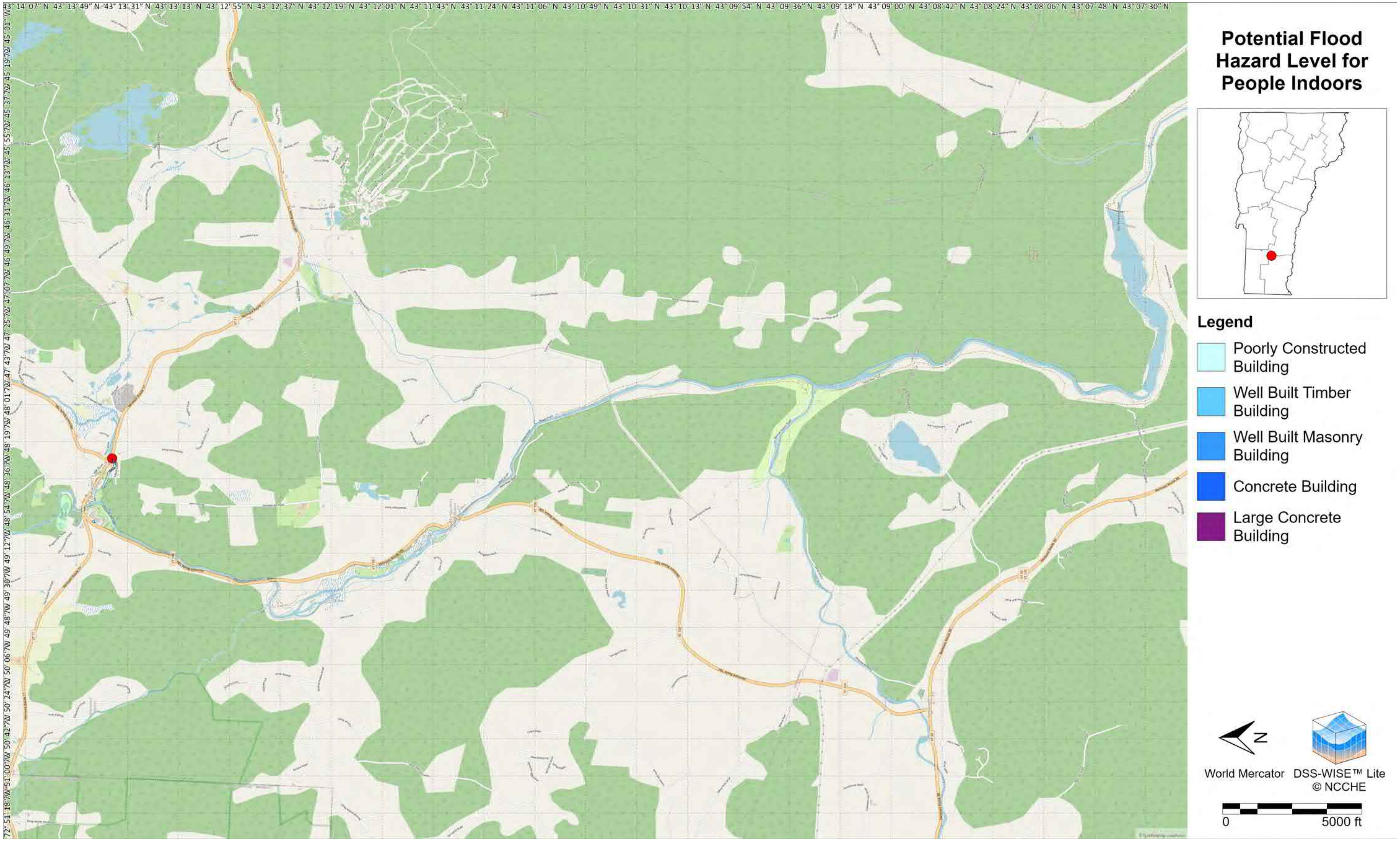
Map 08: Daytime Population Density



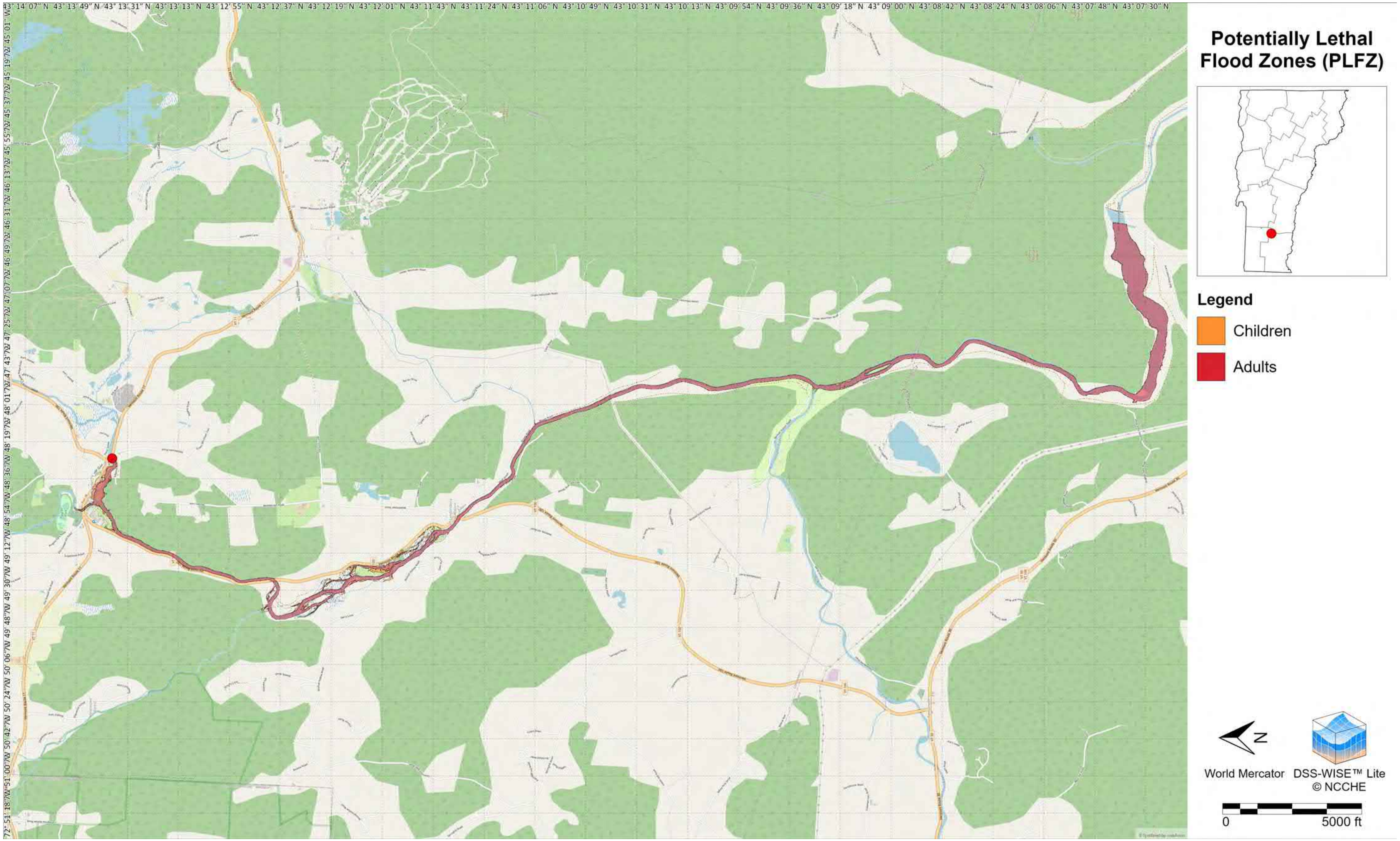
Map 09: Potential Flood Hazard Level for People Outdors



Map 10: Potential Flood Hazard Level for People Indoors



Map 11: Potential Lethal Flood Zones (PLFZ)



Appendix F

Alternative Conceptual Plans

WILLIAMS DAM STUDY EXISTING CONDITIONS

SCALE 1" : 20'

20 0 10 20 40 80

SCALE IN FEET

DATUM:

VERTICAL:	NAVD 88 GPS DERIVED
HORIZONTAL:	NAD 83 GPS DERIVED

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WILLIAMS DAM STUDY (#115.01)

LONDONDERRY, VT

SHEET TITLE

EXISTING CONDITIONS SITE PLAN

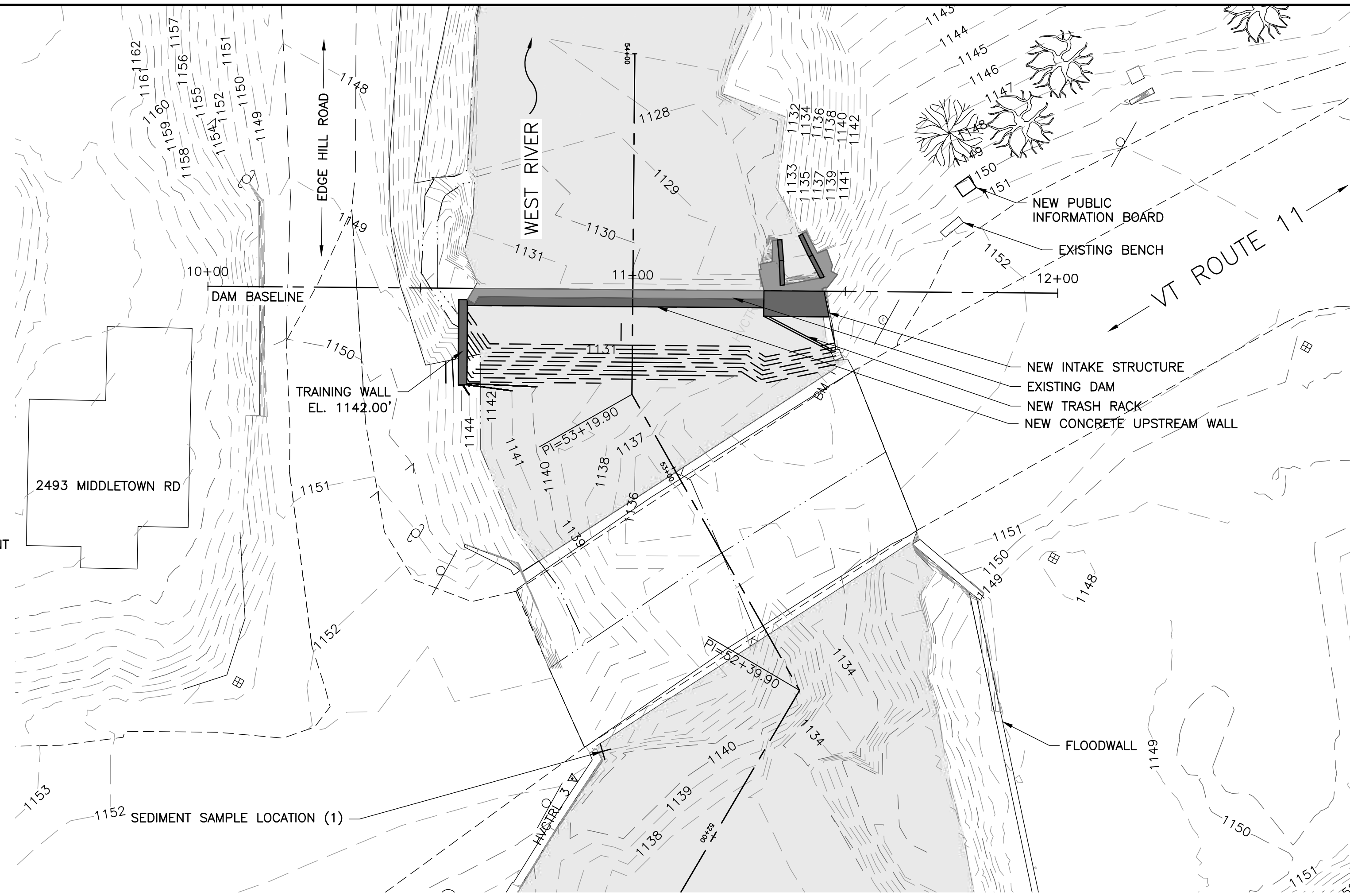
DRAWN BY	DATE
RJL	PROGRESS
CHECKED BY	D&K PROJECT #
	827442
PROJ. ENG.	
CWJ	

SHEET NUMBER

1

REHABILITATION ALTERNATIVE:

1. NEW CONCRETE WALL ON UPSTREAM FACE OF EXISTING DAM.
2. LEAVE EXISTING DAM IN PLACE AND CONSTRUCT A PUBLIC INFORMATION BOARD.
3. NEW LOW LEVEL OUTLET WITH NEW PIPE AND HEADGATE.
4. NEW TRASHRACK/DEBRIS DIVERSION.
5. NEW ABUTMENT TRAINING WALLS AND STONE RIPRAP ALONG ABUTMENTS.
6. DREDGE ACCUMULATED SEDIMENT BEHIND EXISTING DAM AND EXISTING DRY HYDRANT LOCATION.

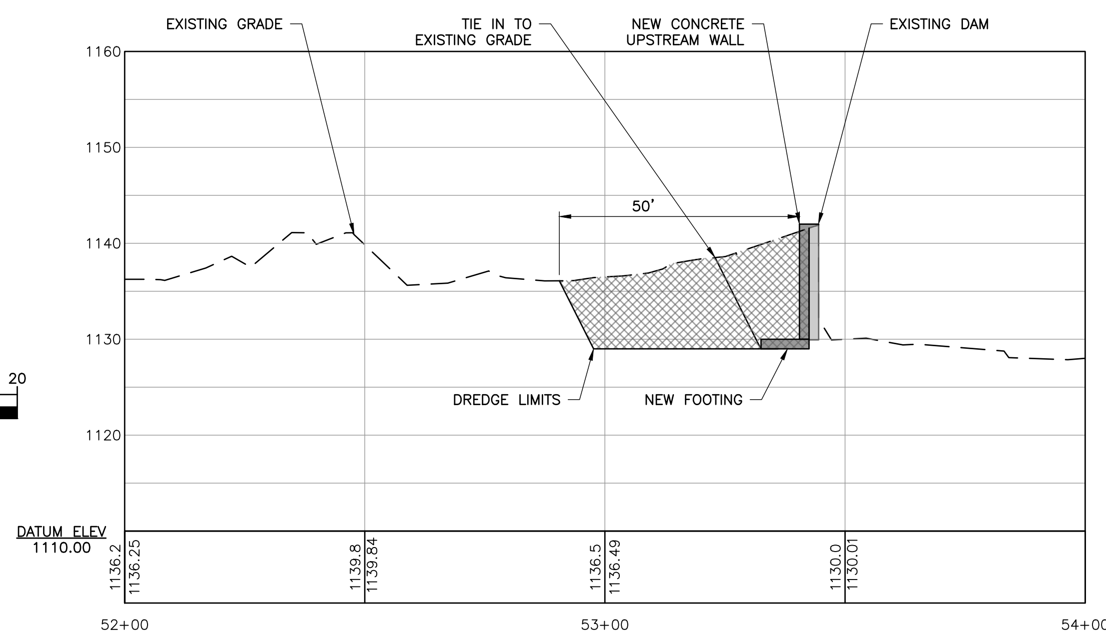


CONCEPTUAL ALTERNATIVE DAM REHABILITATION

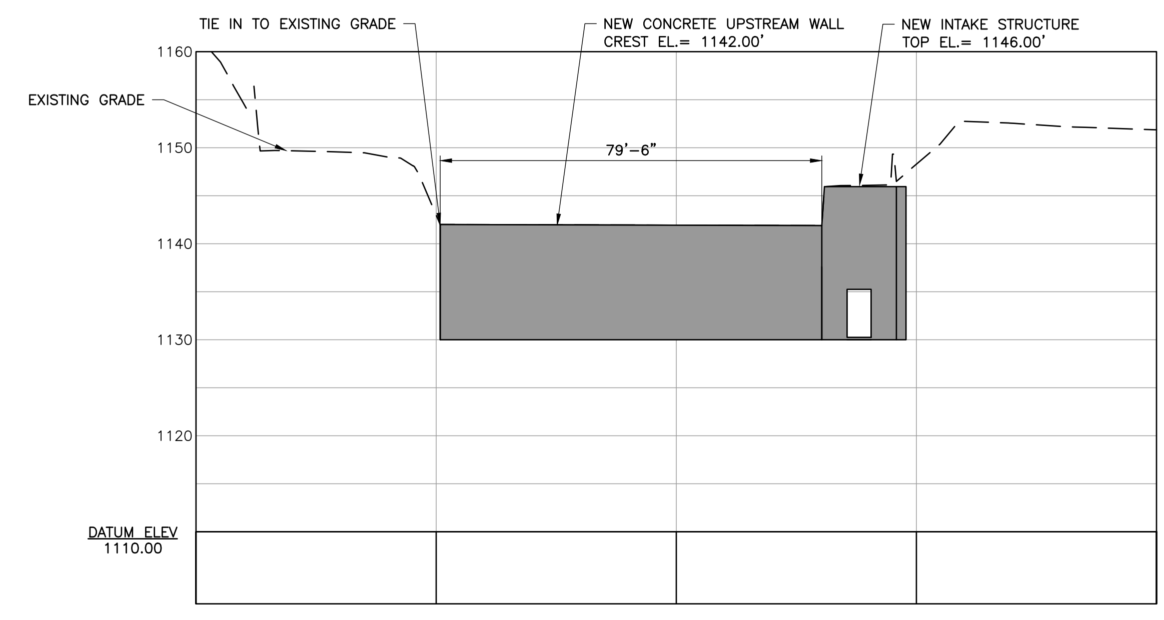
SCALE 1" : 20'

20 0 10 20 40 80

SCALE IN FEET



CHANNEL BASELINE PROFILE



DAM BASELINE PROFILE

10 0 5 10

20 10 0 20

SCALE IN FEET

DATUM:

VERTICAL:	NAVD 88 GPS DERIVED
HORIZONTAL:	NAD 83 GPS DERIVED

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LONDONDERRY, VT

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CONCEPTUAL ALTERNATIVE DAM REHABILITATION

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CHECKED BY	D&K PROJECT # 827442
PROJ. ENG. CWJ	

SHEET NUMBER

2

REHABILITATION ALTERNATIVE:

1. NEW CONCRETE WALL ON UPSTREAM FACE OF EXISTING DAM.
2. LEAVE EXISTING DAM IN PLACE AND CONSTRUCT A PUBLIC INFORMATION BOARD.
3. NEW LOW LEVEL OUTLET WITH NEW PIPE AND HEADGATE.
4. NEW TRASHRACK/DEBRIS DIVERSION.
5. NEW ABUTMENT TRAINING WALLS AND STONE RIPRAP ALONG ABUTMENTS.
6. DREDGE ACCUMULATED SEDIMENT BEHIND EXISTING DAM AND EXISTING DRY HYDRANT LOCATION.

CONCEPTUAL ALTERNATIVE DAM REHABILITATION

SCALE 1" : 10'

10 0 5 10 20 40

SCALE IN FEET

DATUM:

VERTICAL:	NAVD 88 GPS DERIVED
HORIZONTAL:	NAD 83 GPS DERIVED

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DAM REHABILITATION ORTHOIMAGERY

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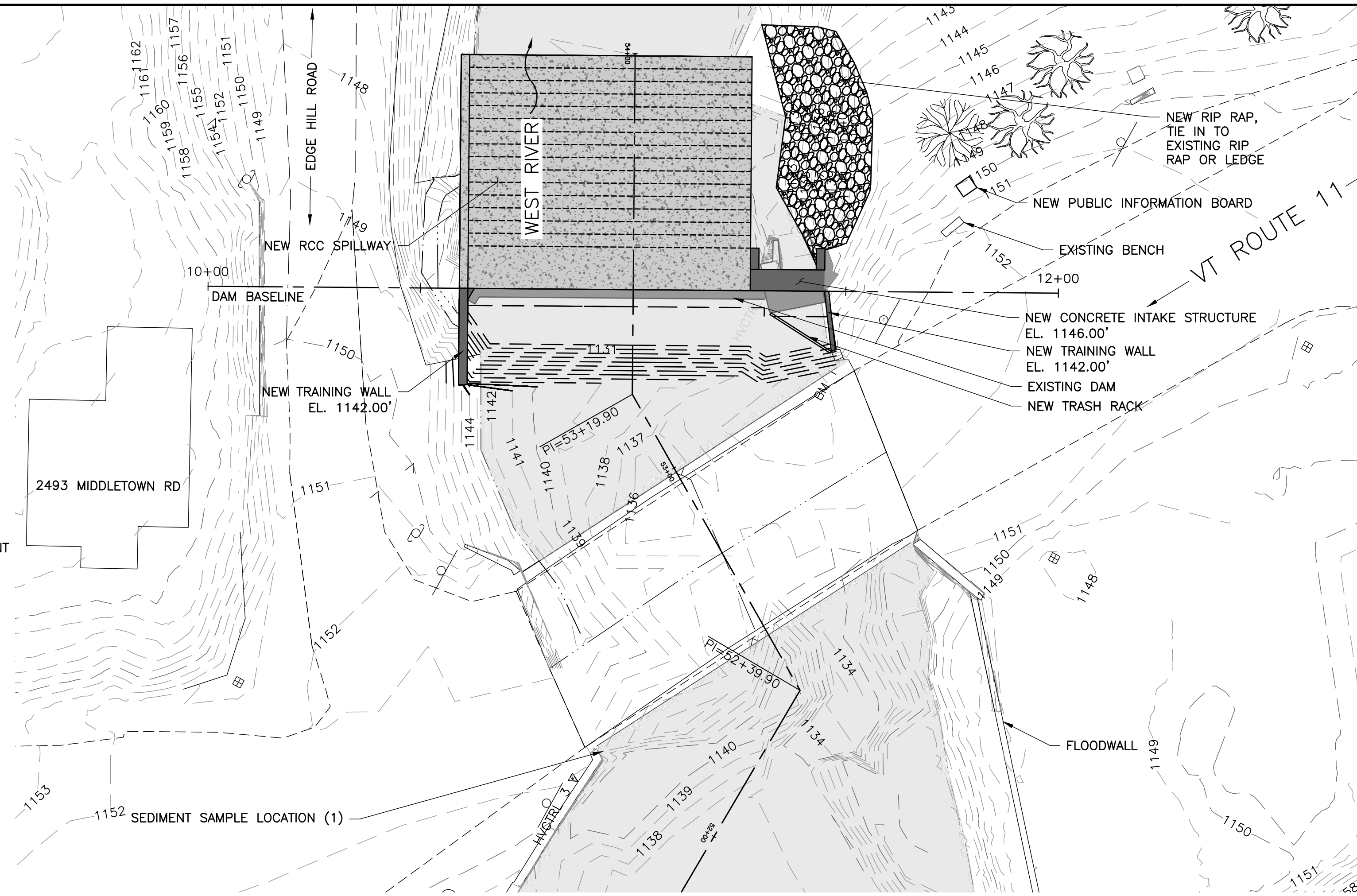
SHEET NUMBER

3

REHABILITATION (B) ALTERNATIVE:

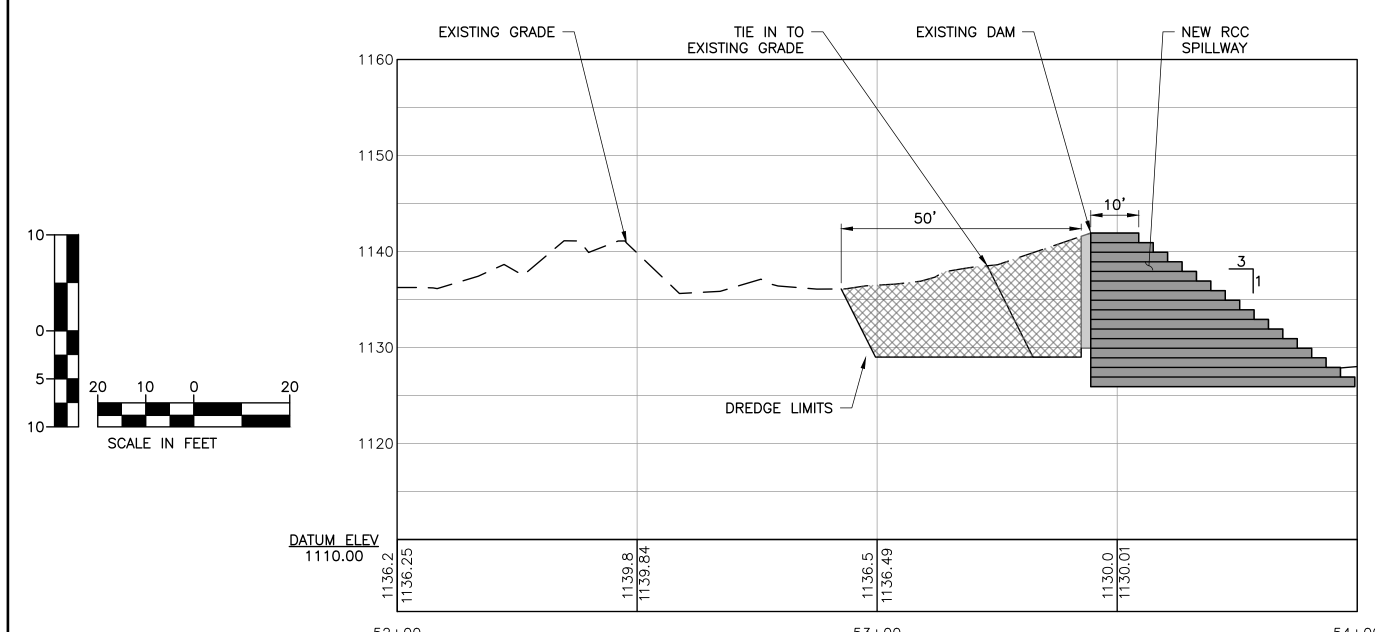
1. NEW CONCRETE WALL ON UPSTREAM FACE OF EXISTING DAM.
2. LEAVE EXISTING DAM IN PLACE AND CONSTRUCT A PUBLIC INFORMATION BOARD.
3. NEW LOW LEVEL OUTLET WITH NEW PIPE AND HEADGATE.
4. NEW TRASHRACK/DEBRIS DIVERSION.
5. NEW ABUTMENT TRAINING WALLS AND STONE RIPRAP ALONG ABUTMENTS.
6. DREDGE ACCUMULATED SEDIMENT BEHIND EXISTING DAM AND EXISTING DRY HYDRANT LOCATION.



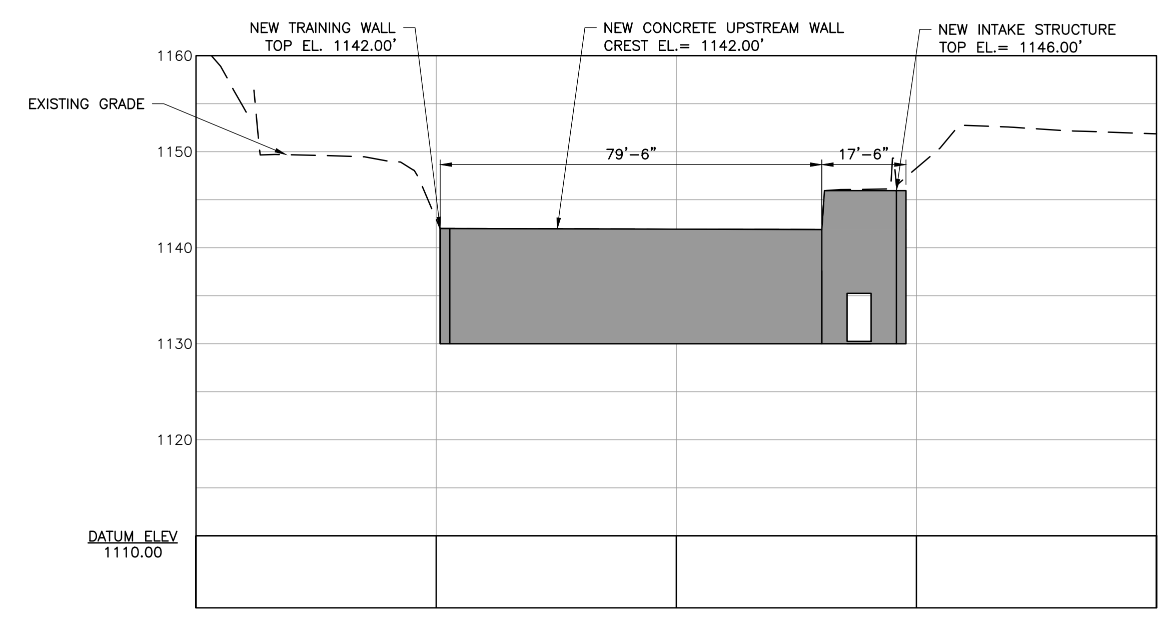
CONCEPTUAL ALTERNATIVE DAM REHABILITATION (B)

SCALE 1" : 20'

SCALE IN FEET



CHANNEL BASELINE PROFILE



DAM BASELINE PROFILE

DATUM:

VERTICAL:	NAVD 88 GPS DERIVED
HORIZONTAL:	NAD 83 GPS DERIVED

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CONCEPTUAL ALTERNATIVE DAM REHABILITATION (B)

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CHECKED BY:	D&K PROJECT #: 827442
PROJ. ENG.: CWJ	

SHEET NUMBER

4

REHABILITATION (B) ALTERNATIVE:

1. NEW CONCRETE WALL ON UPSTREAM FACE OF EXISTING DAM.
2. LEAVE EXISTING DAM IN PLACE AND CONSTRUCT A PUBLIC INFORMATION BOARD.
3. NEW LOW LEVEL OUTLET WITH NEW PIPE AND HEADGATE.
4. NEW TRASHRACK/DEBRIS DIVERSION.
5. NEW ABUTMENT TRAINING WALLS AND STONE RIPRAP ALONG ABUTMENTS.
6. DREDGE ACCUMULATED SEDIMENT BEHIND EXISTING DAM AND EXISTING DRY HYDRANT LOCATION.

CONCEPTUAL ALTERNATIVE DAM REHABILITATION (B)

SCALE 1" : 10'

10 0 5 10 20 40

SCALE IN FEET

DATUM:

VERTICAL:	NAVD 88 GPS DERIVED
HORIZONTAL:	NAD 83 GPS DERIVED

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SHEET TITLE

DAM REHABILITATION (B) ORTHOIMAGERY

DRAWN BY: RJL	DATE: PROGRESS
CHECKED BY:	D&K PROJECT #: 827442
PROJ. ENG.: CWJ	

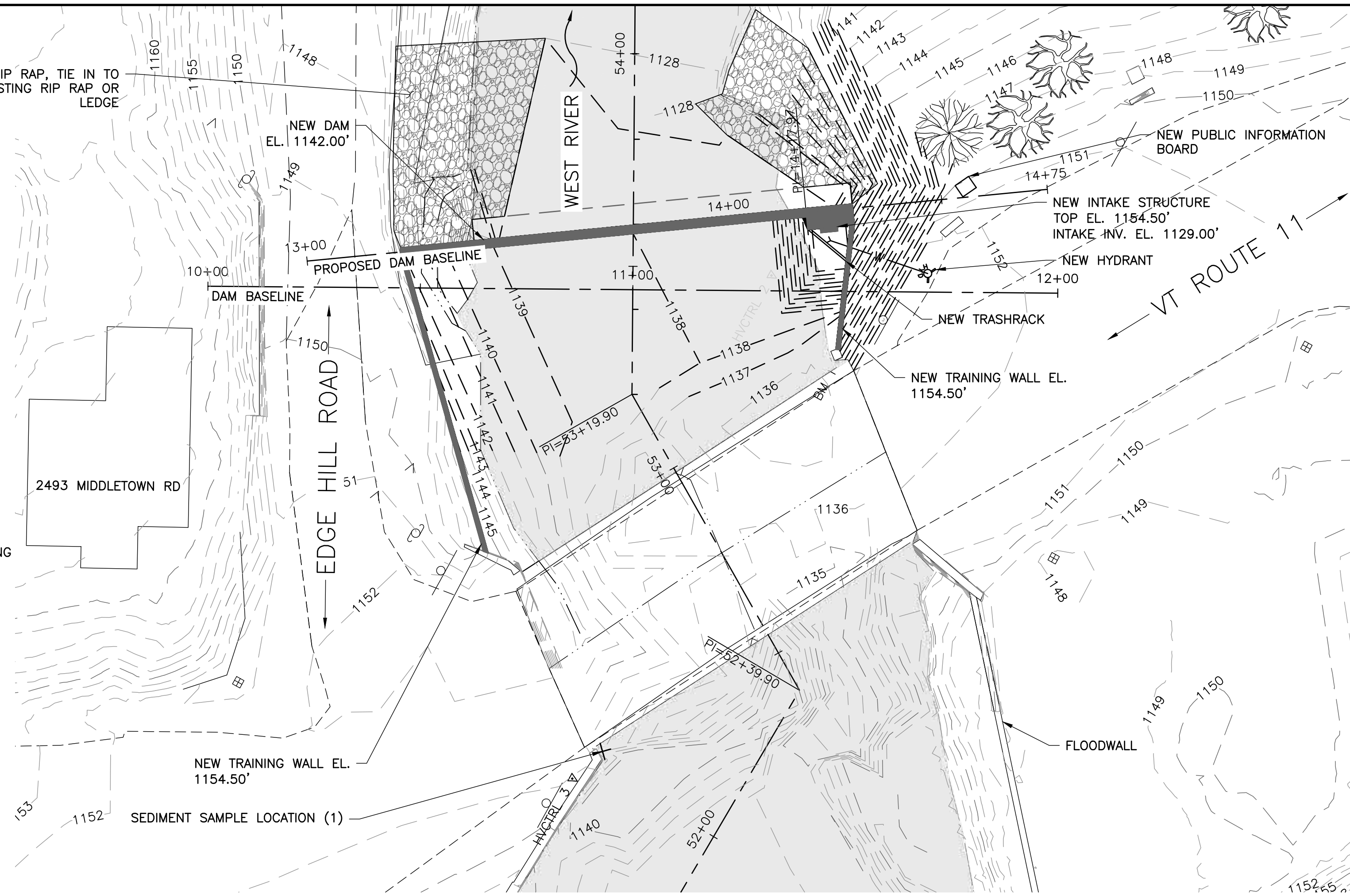
SHEET NUMBER

5

SHEET 5 OF 9

REPLACEMENT ALTERNATIVE:

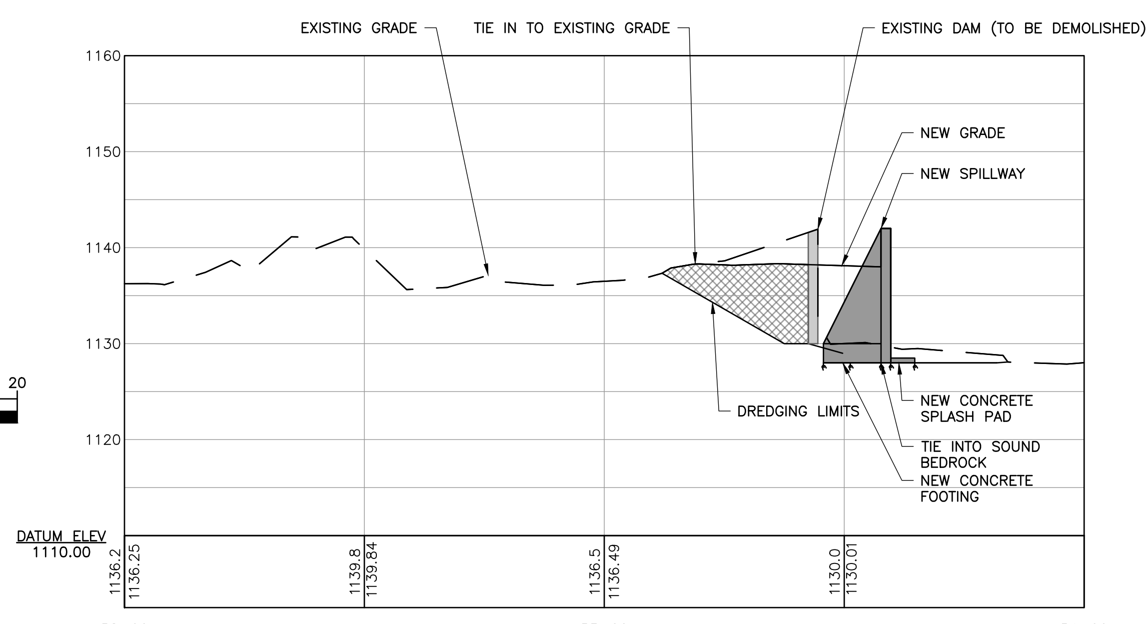
1. NEW CONCRETE DAM APPROXIMATELY 10-FT DOWNSTREAM OF EXISTING DAM.
2. DEMOLISH EXISTING DAM AND CONSTRUCT A PUBLIC INFORMATION BOARD.
3. NEW LOW LEVEL OUTLET WITH NEW PIPE AND HEADGATE.
4. NEW TRASHRACK/DEBRIS DIVERSION.
5. NEW ABUTMENT TRAINING WALLS AND STONE RIPRAP ALONG ABUTMENTS.
6. DREDGE ACCUMULATED SEDIMENT APPROXIMATELY 25-FT UPSTREAM BEHIND EXISTING DAM.
7. ABANDON EXISTING HYDRANT AND CONSTRUCT A NEW HYDRANT AT THE VETERAN'S PARK.



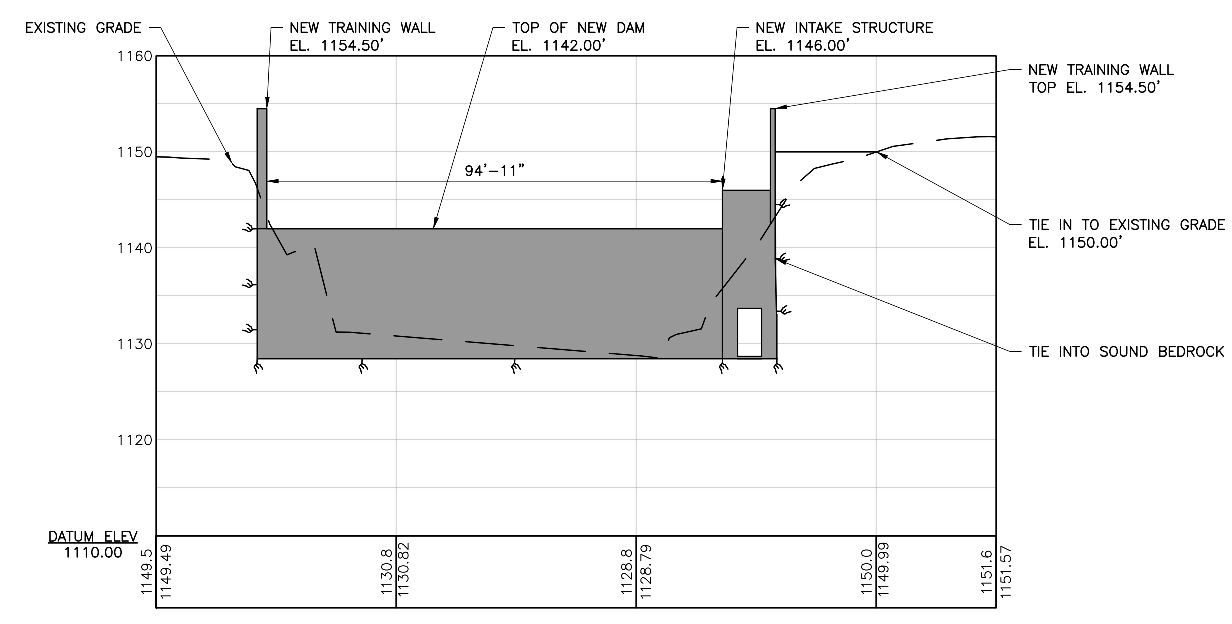
CONCEPTUAL ALTERNATIVE DAM REPLACEMENT

SCALE 1" : 20'

SCALE IN FEET



CHANNEL BASELINE PROFILE



PROPOSED DAM BASELINE PROFILE

DATUM:

VERTICAL:	NAVD 88 GPS DERIVED
HORIZONTAL:	NAD 83 GPS DERIVED

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CONCEPTUAL ALTERNATIVE DAM REPLACEMENT

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CHECKED BY:	D&K PROJECT #: 827442
PROJ. ENG.: CWJ	

SHEET NUMBER

6

REPLACEMENT ALTERNATIVE:

1. NEW CONCRETE DAM APPROXIMATELY 10-FT DOWNSTREAM OF EXISTING DAM.
2. DEMOLISH EXISTING DAM AND CONSTRUCT A PUBLIC INFORMATION BOARD.
3. NEW LOW LEVEL OUTLET WITH NEW PIPE AND HEADGATE.
4. NEW TRASHRACK/DEBRIS DIVERSION.
5. NEW ABUTMENT TRAINING WALLS AND STONE RIPRAP ALONG ABUTMENTS.
6. DREDGE ACCUMULATED SEDIMENT APPROXIMATELY 25-FT UPSTREAM BEHIND EXISTING DAM.
7. ABANDON EXISTING HYDRANT AND CONSTRUCT A NEW HYDRANT AT THE VETERAN'S PARK.

DAM REPLACEMENT ORTHOIMAGERY

SCALE 1" : 10'

20 0 10 20 40 80

SCALE IN FEET

DATUM:

VERTICAL:	NAVD 88 GPS DERIVED
HORIZONTAL:	NAD 83 GPS DERIVED

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SHEET TITLE

DAM REPLACEMENT ORTHOIMAGERY

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PROJ. ENG. CWJ	

SHEET NUMBER

7

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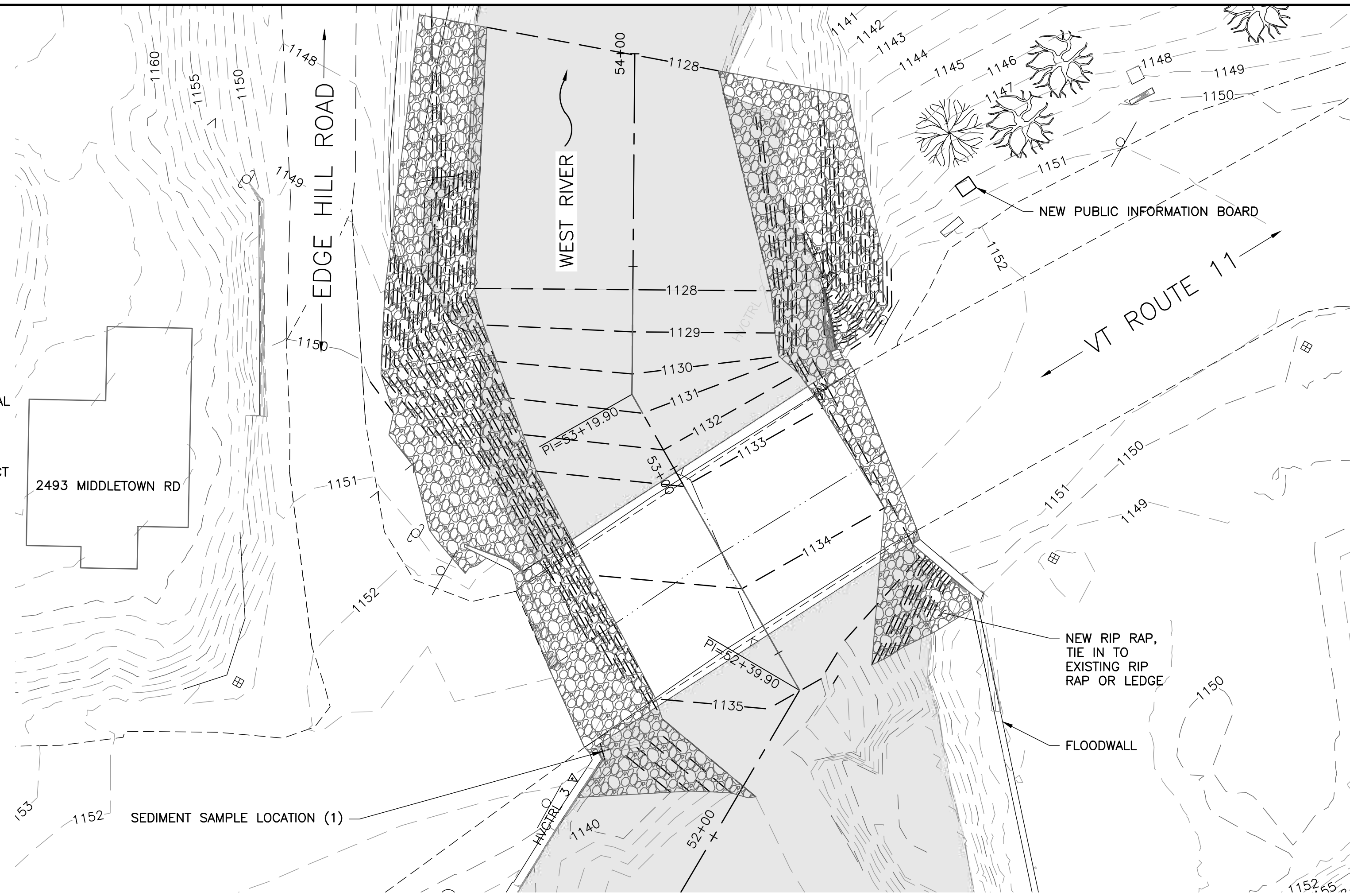
REMOVAL ALTERNATIVE:

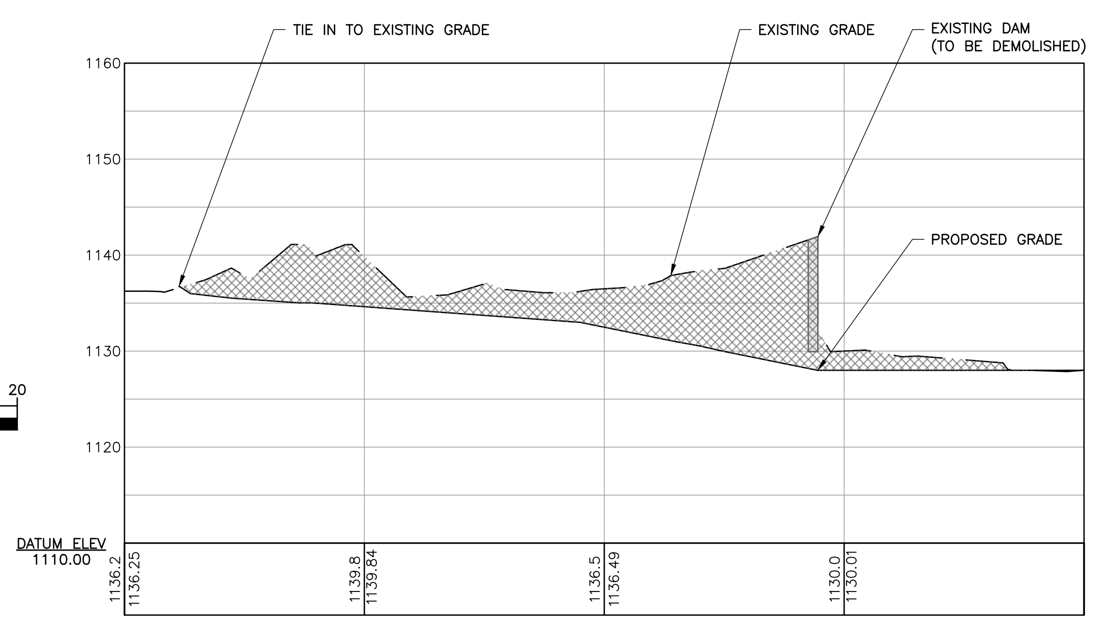
1. DREDGE ACCUMULATED SEDIMENT UPSTREAM OF THE EXISTING DAM TO THE NATURAL CHANNEL BOTTOM.
2. NEW STONE RIPRAP ALONG RIVER BANKS.
3. DEMOLISH THE EXISTING DAM. TO PRESERVE ITS HISTORIC SIGNIFICANCE, CONSTRUCT A PUBLIC INFORMATION BOARD IN VETERAN'S PARK.
4. ABANDON EXISTING HYDRANT LOCATION.



CONCEPTUAL ALTERNATIVE DAM REMOVAL

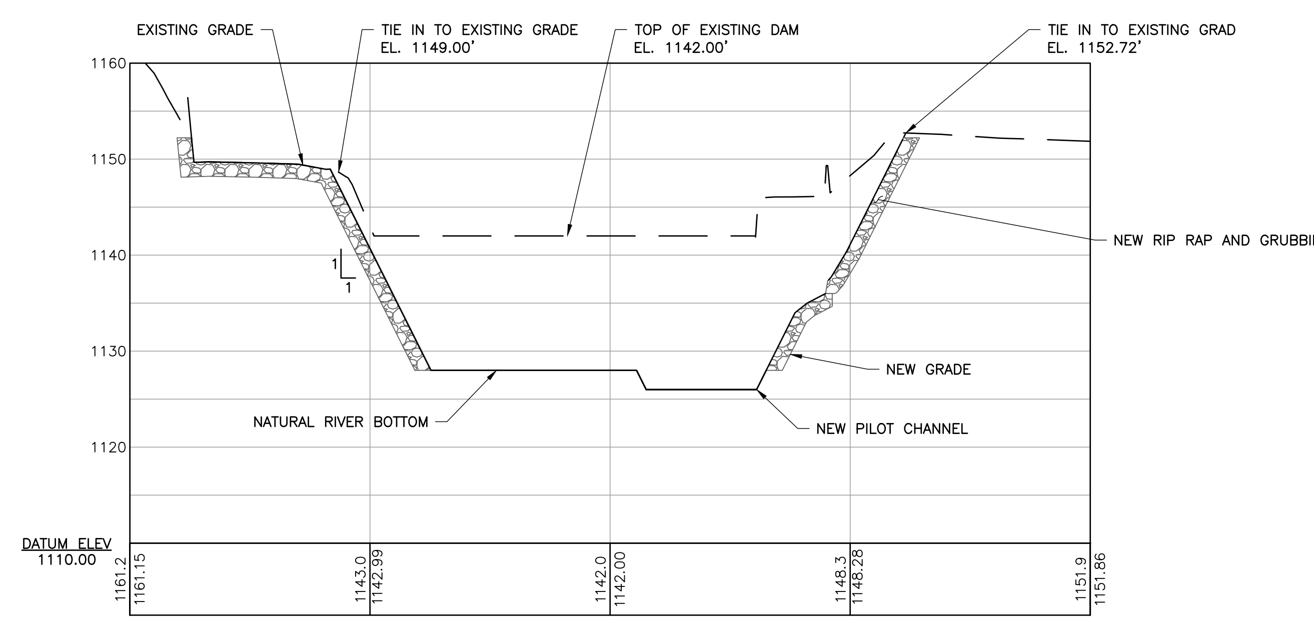
SCALE 1" : 20'

SCALE IN FEET



CHANNEL BASELINE PROFILE

SCALE IN FEET



RIVER CHANNEL SECTION

DATUM:

VERTICAL:	NAVD 88 GPS DERIVED
HORIZONTAL:	NAD 83 GPS DERIVED

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WILLIAMS DAM STUDY (#115.01)

LONDONDERRY, VT

SHEET TITLE

CONCEPTUAL ALTERNATIVE DAM REMOVAL

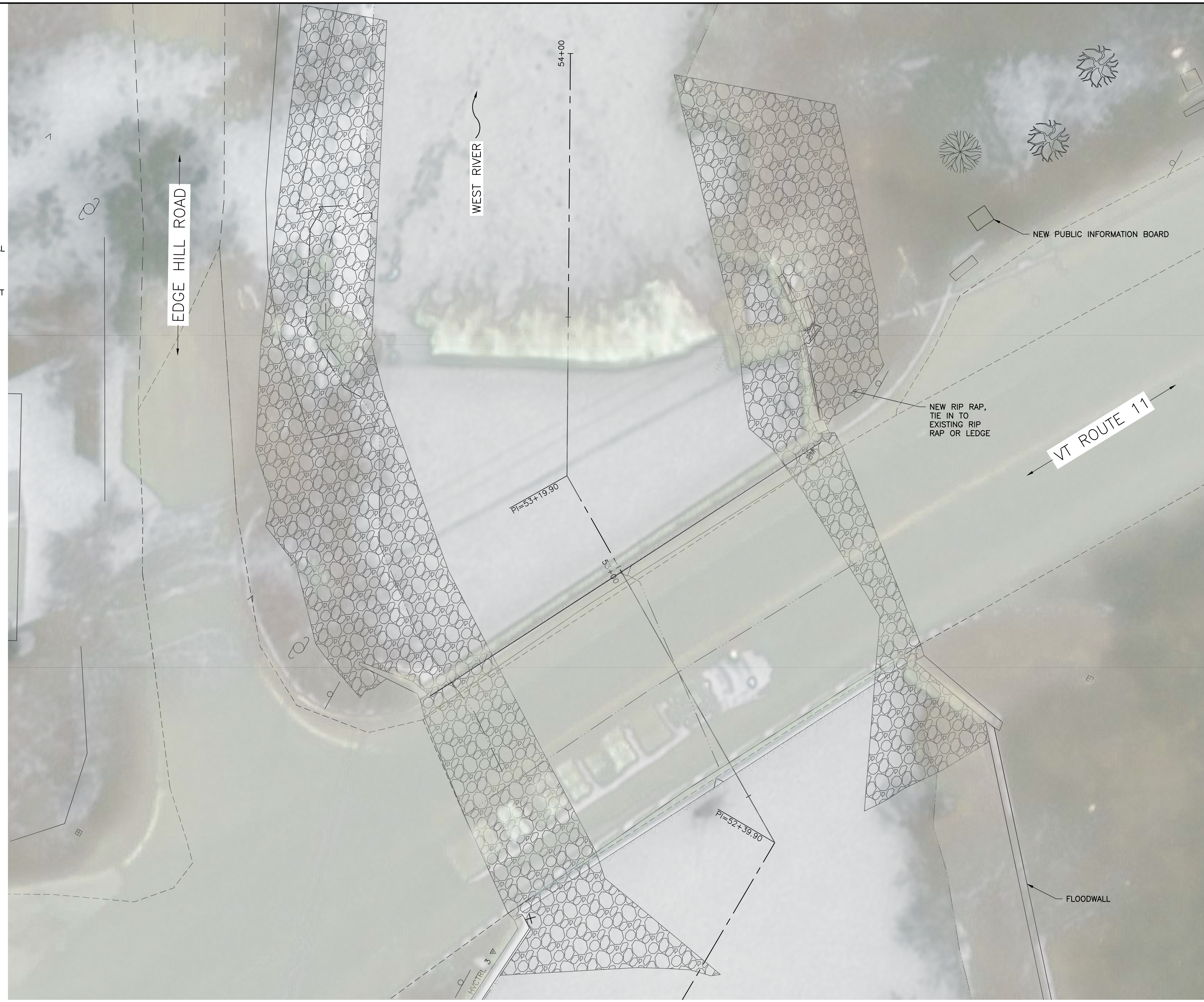
DRAWN BY RJL	DATE PROGRESS
CHECKED BY	D&K PROJECT # 827442
PROJ. ENG. CWJ	

SHEET NUMBER

8

REMOVAL ALTERNATIVE:

1. DREDGE ACCUMULATED SEDIMENT UPSTREAM OF THE EXISTING DAM TO THE NATURAL CHANNEL BOTTOM.
2. NEW STONE RIPRAP ALONG RIVER BANKS.
3. DEMOLISH THE EXISTING DAM. TO PRESERVE ITS HISTORIC SIGNIFICANCE, CONSTRUCT A PUBLIC INFORMATION BOARD IN VETERAN'S PARK.
4. ABANDON EXISTING HYDRANT LOCATION.



CONCEPTUAL ALTERNATIVE DAM REMOVAL
SCALE 1" : 20'

20 0 10 20 40 80
SCALE IN FEET

DATUM:
VERTICAL: NAVD 88 GPS DERIVED
HORIZONTAL: NAD 83 GPS DERIVED

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DuBois & King inc.
6 GREEN TREE DR.
S. BURLINGTON, VT 05401
TEL: (802) 728-3376
FAX: (866) 783-7101
www.dubois-king.com

PROFESSIONAL SEAL

NOT FOR CONSTRUCTION

NO.	DATE	DESCRIPTION	BY	CK'D

TOWN OF LONDONDERRY
100 OLD SCHOOL STREET
S. LONDONDERRY, VT 05155

WILLIAMS DAM STUDY (#115.01)

LONDONDERRY, VT

SHEET TITLE

DAM REMOVAL ORTHOIMAGERY

DRAWN BY RJL	DATE PROGRESS
CHECKED BY	D&K PROJECT # 827442
PROJ. ENG. CWJ	

SHEET NUMBER

9

Appendix G

Alternative Opinion of Probable Construction Costs

Town of Londonderry
William's Dam Study

Conceptual Alternative: Dam Rehabilitation
Opinion of Probable Construction Costs

ITEM NO.	DESCRIPTION	UNITS	ESTIMATED QUANTITY	UNIT COST	TOTAL
DAM REHABILITATION					
1	Upstream CIP Concrete Wall	CY	200	$ 1,800.00	$ 360,000.00
2	Sediment Excavation	CY	950	$ 18.00	$ 17,100.00
3	Sediment Haul	CY	950	$ 22.00	$ 20,900.00
				DAM REPLACEMENT SUBTOTAL	$ 398,000
CHANNEL RESTORATION					
4	Silt Fencing	LF	120	$ 4.10	$ 492.00
5	Engineered Log Jams	EA	3	$ 5,000.00	$ 15,000.00
6	Channel Vegetation (Seed/mulch)	LS	1	$ 5,000.00	$ 5,000.00
7	Topsoil	CY	25	$ 35.40	$ 885.00
8	Seed	LB	5	$ 8.73	$ 43.65
9	Fertilizer	LB	10	$ 3.83	$ 38.30
10	Hay Mulch	TON	1	$ 857.35	$ 857.35
11	Grubbing Material	SY	20	$ 3.83	$ 76.60
				CHANNEL RESTORATION SUBTOTAL	$ 22,392.90
ADDITIONAL ITEMS					
13	Survey Layout	DAY	1	$ 2,000.00	$ 2,000.00
14	Stabilized Construction Entrance	CY	50	$ 52.52	$ 2,626.00
15	Inlet Protection Device, Type 1	EA	3	$ 171.67	$ 515.01
16	Rolled Erosion Control Product	SY	100	$ 1.66	$ 166.00
17	Reset Roadway Signs	EA	1	$ 27.14	$ 27.14
18	Remove and Reset Roadway Lighting	EA	1	$ 1,000.00	$ 1,000.00
				ADDITIONAL ITEMS SUBTOTAL	$ 6,334
GENERAL					
19	Mobilization (10% of Construction Costs)	LS	1	$ 43,000.00	$ 43,000.00
20	EPSC (5% of Construction Costs)	LS	1	$ 22,000.00	$ 22,000.00
21	Traffic Control (10% of Construction Costs)	LS	1	$ 43,000.00	$ 43,000.00
22	Control of Water (20% of Construction Costs)	LS	1	$ 86,000.00	$ 86,000.00
				GENERAL SUBTOTAL	$ 194,000.00

CONSTRUCTION ITEMS SUB-TOTAL (rounded to nearest $1,000)	=	$621,000
30% CONTINGENCY	=	$187,000
TOTAL CONSTRUCTION COST	=	**$808,000**

Town of Londonderry
William's Dam Study

Conceptual Alternative: Dam Rehabilitation (B)
Opinion of Probable Construction Costs

ITEM NO.	DESCRIPTION	UNITS	ESTIMATED QUANTITY	UNIT COST	TOTAL
DAM REHABILITATION					
1	ROLLER COMPACTED CONCRETE	CY	740	$ 200	$ 148,000
2	STRUCTURAL CONCRETE	CY	90	$ 1,800	$ 162,000
2	Sediment Excavation	CY	600	$ 10	$ 6,000
3	Sediment Haul	CY	600	$ 20	$ 12,000
				DAM REPLACEMENT SUBTOTAL	$ 328,000
CHANNEL RESTORATION					
4	Silt Fencing	LF	12	$ 4	$ 49
5	Engineered Log Jams	EA	3	$ 5,000	$ 15,000
6	Channel Vegetation (Seed/mulch)	LS	1	$ 5,000	$ 5,000
7	Topsoil	CY	25	$ 35	$ 885
8	Seed	LB	5	$ 9	$ 44
9	Fertilizer	LB	10	$ 4	$ 38
10	Hay Mulch	TON	1	$ 857	$ 857
11	Grubbing Material	SY	20	$ 4	$ 77
				CHANNEL RESTORATION SUBTOTAL	$ 21,950
ADDITIONAL ITEMS					
13	Survey Layout	DAY	1	$ 2,000	$ 2,000
14	Stabilized Construction Entrance	CY	30	$ 53	$ 1,576
15	Inlet Protection Device, Type 1	EA	3	$ 172	$ 515
16	Rolled Erosion Control Product	SY	200	$ 2	$ 332
17	Reset Roadway Signs	EA	2	$ 27	$ 54
18	Remove and Reset Roadway Lighting	EA	2	$ 1,000	$ 2,000
				ADDITIONAL ITEMS SUBTOTAL	$ 6,477
GENERAL					
19	Mobilization (Assume 10% of Construction Costs)	LS	1	$ 36,000	$ 36,000
20	EPSC (5% of Construction Costs)	LS	1	$ 18,000	$ 18,000
21	Traffic Control (10% of Construction Costs)	LS	1	$ 36,000	$ 36,000
22	Control of Water (20% of Construction Costs)	LS	1	$ 72,000	$ 72,000
				GENERAL SUBTOTAL	$ 162,000

CONSTRUCTION ITEMS SUB-TOTAL (rounded to nearest $1,000)	=	$ 519,000
30% CONTINGENCY	=	$ 156,000
TOTAL CONSTRUCTION COST	=	**$ 675,000**

DuBois & King inc.

Town of Londonderry
William's Dam Study

Conceptual Alternative: Dam Replacement
Opinion of Probable Construction Costs

ITEM NO.	DESCRIPTION	UNITS	ESTIMATED QUANTITY	UNIT COST	TOTAL
DAM REPLACEMENT					
1	CONCRETE CLASS A	CY	290	$ 1,800.00	$ 522,000
2	Sediment Excavation	CY	950	$ 18.00	$ 17,100
3	Sediment Haul	CY	950	$ 22.00	$ 20,900
				DAM REPLACEMENT SUBTOTAL	$ 560,000
DAM REMOVAL					
4	Concrete Demolition	CY	175	$ 23.82	$ 4,169
5	Rock Excavation	CY	225	$ 40.68	$ 9,153
				DAM REMOVAL SUBTOTAL	$ 13,322
CHANNEL RESTORATION					
6	Silt Fencing	LF	310	$ 4.10	$ 1,271
7	Engineered Log Jams	EA	3	$ 5,000.00	$ 15,000
8	Riprap, Heavy Type	CY	260	$ 63.13	$ 16,414
9	Channel Vegetation (Seed/mulch)	LS	1	$ 5,000.00	$ 5,000
10	Topsoil	CY	70	$ 35.40	$ 2,478
11	Seed	LB	10	$ 8.73	$ 87
12	Fertilizer	LB	20	$ 3.83	$ 77
13	Hay Mulch	TON	1	$ 857.35	$ 857
14	Grubbing Material	SY	130	$ 3.83	$ 498
				CHANNEL RESTORATION SUBTOTAL	$ 41,682
ADDITIONAL ITEMS					
15	Survey Layout	DAY	1	$ 2,000.00	$ 2,000
16	Stabilized Construction Entrance	CY	50	$ 52.52	$ 2,626
17	Inlet Protection Device, Type 1	EA	3	$ 171.67	$ 515
18	Rolled Erosion Control Product	SY	200	$ 1.66	$ 332
19	Reset Roadway Signs	EA	2	$ 27.14	$ 54
20	Dry Hydrant System	LS	1	$ 5,000.00	$ 5,000
20	Remove and Reset Roadway Lighting	EA	2	$ 1,000.00	$ 2,000
				ADDITIONAL ITEMS SUBTOTAL	$ 12,527
GENERAL					
21	Mobilization (10% of Construction Costs)	LS	1	$ 63,000.00	$ 63,000
22	EPSC (5% of Construction Costs)	LS	1	$ 32,000.00	$ 32,000
23	Traffic Control (10% of Construction Costs)	LS	1	$ 63,000.00	$ 63,000
24	Control of Water (20% of Construction Costs)	LS	1	$ 126,000.00	$ 126,000
				GENERAL SUBTOTAL	$ 284,000
	CONSTRUCTION ITEMS SUB-TOTAL (rounded to nearest $1,000)			=	$ 912,000
	30% CONTINGENCY			=	$ 274,000
	TOTAL CONSTRUCTION COST			=	**$ 1,186,000**

Town of Londonderry
William's Dam Study

Conceptual Alternative: Dam Removal
Opinion of Probable Construction Costs

ITEM NO.	DESCRIPTION	UNITS	ESTIMATED QUANTITY	UNIT COST	TOTAL
DAM REMOVAL					
1	Concrete Demolition	CY	170	$ 23.82	$ 4,049.40
2	Rock Excavation	CY	210	$ 40.68	$ 8,542.80
				DAM REMOVAL SUBTOTAL	$ 12,592
CHANNEL RESTORATION					
3	Sediment Excavation	CY	3,000	$ 18.00	$ 54,000.00
4	Sediment Haul	CY	3,000	$ 22.00	$ 66,000.00
5	Silt Fence	LF	420	$ 4.10	$ 1,722.00
6	Riprap, Heavy Type	CY	260	$ 63.13	$ 16,413.80
7	Engineered Log Jams	EA	3	$ 5,000.00	$ 15,000.00
8	Channel Vegetation (Seed/mulch)	LS	1	$ 5,000.00	$ 5,000.00
9	Topsoil	CY	40	$ 35.40	$ 1,416.00
10	Seed	LB	10	$ 8.73	$ 87.30
11	Fertilizer	LB	30	$ 3.83	$ 114.90
12	Hay Mulch	TON	1	$ 857.35	$ 857.35
13	Grubbing Material	SY	400	$ 3.83	$ 1,532.00
				CHANNEL RESTORATION SUBTOTAL	$ 162,143.35
ADDITIONAL ITEMS					
14	Survey Layout	DAY	1	$ 2,000.00	$ 2,000.00
15	Stabilized Construction Entrance	SY	110	$ 52.52	$ 5,777.20
16	Stabilized Construction Entrance	CY	110	$ 52.52	$ 5,777.20
17	Rolled Erosion Control Product	SY	250	$ 1.66	$ 415.00
18	Reset Roadway Signs	EA	3	$ 27.14	$ 81.42
19	Remove and Reset Roadway Lighting	EA	2	$ 1,000.00	$ 2,000.00
				ADDITIONAL ITEMS SUBTOTAL	$ 16,051
GENERAL					
20	Mobilization (10% of Construction Costs)	LS	1	$ 20,000.00	$ 20,000.00
21	EPSC (5% of Construction Costs)	LS	1	$ 10,000.00	$ 10,000.00
22	Traffic Control (10% of Construction Costs)	LS	1	$ 20,000.00	$ 20,000.00
23	Control of Water (20% of Construction Costs)	LS	1	$ 39,000.00	$ 39,000.00
				GENERAL SUBTOTAL	$ 89,000.00

CONSTRUCTION ITEMS SUB-TOTAL (rounded to nearest $1,000)	=	$280,000
30% CONTINGENCY	=	$84,000
TOTAL CONSTRUCTION COST	=	**$364,000**

Appendix H

Alternative Permitting Information Sheets

State of Vermont
PERMIT AND LICENSE INFORMATION

DAMS

SUMMARY DESCRIPTION OF PERMIT

A permit is required to ensure that the construction, reconstruction, alteration or removal of dams is carried out to serve the public good and provide adequately for the public safety.

Owners of dams capable of impounding more than 500,000 cubic feet of water are responsible for the payment of the **annual fee**, based on the hazard class of the dam: low hazard dams $200/year, significant hazard dams $350/year, and high hazard dams $1,000/year.

EXAMPLE OF REGULATED ACTIVITY

Construction, enlargement, raising, lowering, remodeling, reconstruction, breaching or otherwise altering any dam, pond or impoundment not related to generation of electric energy for public use or part of a public utility system which is or will be capable of impounding more than 500,000 cubic feet of water or other liquid, as measured to the top of the dam.

INFORMATION REQUIRED

Requires submittal of completed application form, fee, plans and specifications and design data. May require public information meeting 10 VSA Chapter 170.

WEB ADDRESS

http://dec.vermont.gov/facilities-engineering/dam-safety/dam-ownership-and-responsibility/dam-orders

ADMINISTERING AGENCY

AGENCY OF NATURAL RESOURCES
DEPARTMENT OF ENVIRONMENTAL CONSERVATION
FACILITIES ENGINEERING DIVISION

CONTACT: Ben Green, P.E. Dam Safety Engineer
802-622-4093 benjamin.green@vermont.gov
Steven Hanna, Dam Safety Engineer
802-490-6123 steven.hanna@vermont.gov

ADDRESS: Facilities Engineering Division
1 National Life Drive
Montpelier, Vermont 05620-3510

AUTHORITY

10 VSA Chapter 43

APPLICABLE RULES

If dam impounds less than 500,000 cubic feet it may require a Stream Alteration Permit (10 VSA Chapter 41, Subchapter 2), or Stream Obstruction Permit (10 VSA Chapter 111, § 4607) (Issued by the Commissioner of Fish and Wildlife). If hydroelectric project, it is regulated under 10 VSA Chapter 43 of the Public Utility Commission. May also require a Conditional Use Determination under Wetlands Rules and US Army Corps of Engineers permit. See general information about pond construction on Sheet 32.1.

APPEAL PROCESS	Within 30 days of the date of an act or decision, any person aggrieved by an act or decision of the secretary, or any party by right, may appeal to the environmental court in accordance with the provisions of 10 VSA Chapter 220.

State of Vermont
PERMIT AND LICENSE INFORMATION

WETLANDS PERMIT

SUMMARY DESCRIPTION OF PROGRAM

The purpose of this program is to protect significant wetlands in Vermont. The Vermont Wetland Rules establish a three-tier classification system for wetlands.

EXAMPLE OF REGULATED ACTIVITY

Placement of fill for an access road, land clearing, excavation of ponds. Any activity within the wetland or 50-foot buffer zone.

CRITERIA FOR JURISDICTION

Class I and Class II wetlands are designated significant wetlands based on the function and value they provide. The Vermont Wetland Rules (VWR) refer to criteria for presuming a wetland is significant under Section 4.6 of the VWR which includes connection to other surface waters, size of a half-acre or more, and mapped wetlands. Classification can be assigned by the Secretary for mapped or unmapped wetlands through a Wetland Determination. Activities that are allowed within the significant wetlands and their adjacent buffer zones are listed in Section 6 of the VWR, provided there is no draining, dredging, filling, grading or alteration of the water flow. All uses that are not allowed uses require either an Individual Wetland Permit or a Vermont Wetland General Permit. If an individual is unsure whether a permit is required, they should contact their District Wetland Ecologist.

INFORMATION REQUIRED

Application forms for permits and determinations are available from the Vermont Wetlands Office, website, and from our website.

WEB ADDRESS

http://dec.vermont.gov/watershed/wetlands

FEES

Minimum Application Fee $240.00 PLUS:

(A) $0.75 per square foot of proposed impact to Class I or II wetlands;

(B) $0.25 per square foot of proposed impact to Class I or II wetland buffers;

(C) Maximum fee, for the conversion of Class II wetlands or wetland buffers to cropland use, $200.00 per application. “Cropland” means land that is used for the production of agricultural crops, including row crops, fibrous plants, pasture, fruit-bearing bushes, trees or vines and the production of Christmas trees;

(D) Clearing and maintenance of forested wetland corridors for utility lines, pipelines and ski trails: $0.25 per square foot of proposed impact.

APPLICATION TIME FRAME

The performance standard for processing a complete application is 90 days without a meeting and 120 days with a meeting.

ADMINISTERING AGENCY	**AGENCY OF NATURAL RESOURCES** **DEPARTMENT OF ENVIRONMENTAL CONSERVATION** **WATERSHED MANAGEMENT DIVISION** CONTACT: Contact your regional District Wetlands Ecologist for site-specific questions (802) 490-6195 ANR.WSMDWetlands@vermont.gov ADDRESS: Watershed Management Division 1 National Life Drive, Davis 3 Montpelier, VT 05620-3522
AUTHORITY	10 V.S.A. § 905(a)(7-9) & V.S.A. § 2822(j)(26)
APPLICABLE RULES	Vermont Wetland Rules Effective February 23, 1990, and amended April 1, 2017
APPEAL PROCESS	Any person aggrieved by an act or decision of the Secretary may appeal to the Environmental Court within 30 days of the date of the act or decision in accordance with 10 VSA Chapter 220 and the Vermont Rules of Environmental Court Proceedings.
OTHER PERMITS AND APPROVALS	Contact a Permit Specialist for a Project Review Sheet, see: http://dec.vermont.gov/environmental-assistance/permits.

State of Vermont
PERMIT AND LICENSE INFORMATION

STREAM ALTERATIONS & CROSSINGS

SUMMARY DESCRIPTION OF PERMIT

This permit regulates the alteration of streams. Regulated activities may be covered under either an individual or general permit. Permit review protects against creation of flood hazards and damage to fish life; protects rights of neighboring landowners; and, with respect to the stream alteration activity, assures compliance with Vermont Water Quality Standards.

EXAMPLE OF REGULATED ACTIVITY

Streambank stabilization, mineral prospecting, municipal roadway improvements requiring instream work, utility crossings under streambeds, municipal or private bridge construction or repair.

CRITERIA FOR JURISDICTION

Movement, excavation or fill of 10 or more cubic yards annually in any perennial stream, or construction or maintenance of a berm in a flood hazard area or river corridor. No person may remove gravel from any watercourse primarily for construction or sale. Exemptions for: emergency protective measures with municipal authorization and reporting and implementation requirements, removal of 50 cubic yards or up to 10 cubic yards in Outstanding Resource Waters annually for riparian landowners with reporting requirements, and Required Agricultural Practices as defined by the Commissioner of Agriculture. Approval required for municipal or private stream crossings on perennial streams.

INFORMATION REQUIRED

Requires specific information regarding project location and extent, adjacent and opposite landowners, working dates, maps/drawings, plans and notification of application to adjoining landowners and the municipality.

WEB ADDRESS

http://dec.vermont.gov/watershed/rivers/river-management

FEES

Individual Permit:	$350.00 (municipalities are not exempt)
General Permit:	New, repair, or replacement culverts and bridges and restoration projects: $200.00 (municipalities are not exempt)
General Permit:	Next flood or emergency protective measures: No Fee

APPLICATION TIME FRAME

The performance standard for processing a complete application is 40 days.

ADMINISTERING AGENCY

AGENCY OF NATURAL RESOURCES
DEPARTMENT OF ENVIRONMENTAL CONSERVATION
WATERSHED MANAGEMENT DIVISION

Map of the regions served by the River Management Engineers:
http://dec.vermont.gov/sites/dec/files/wsm/rivers/docs/RME_districts.pdf

For Northwestern Vermont:
Chris Brunelle, River Management Engineer
Essex Regional Office
Work Cell 802-777-5328: Fax: 802 879-3871
Email: chris.brunelle@vermont.gov

For Northeastern Vermont:
Patrick Ross, P.E. River Management Engineer
St. Johnsbury Regional Office
Work Cell: 802-279-1143 Fax: 802-748-6687
Email: patrick.ross@vermont.gov

For Central Vermont:
Jaron Borg, River Management Engineer
Central Montpelier Office
Work Cell: 802-371-8342 Fax: 802-828-1544
Email: jaron.borg@vermont.gov

For Southwestern Vermont:
Josh Carvajal, River Management Engineer
Rutland Regional Office
Work Cell: 802-490-6163 Fax: 802-786-5915
Email: joshua.carvajal@vermont.gov

For Southeastern Vermont:
Scott Jensen, River Management Engineer
Springfield Regional Office
Work Cell: 802-490-6962 Fax: 802-885-8890
Email: scott.jensen@vermont.gov

AUTHORITY

10 VSA Chapter 41

APPEAL PROCESS

Effective January 31, 2005, within 30 days of the date of an act or decision, any person aggrieved by an act or decision of the secretary, or any party by right, may appeal to the environmental court in accordance with the provisions of 10 VSA Chapter 220.

OTHER PERMITS

Local Flood Hazard Area permits, U.S. Army Corps of Engineers permits, 401 Water Quality Certification, ANR Flood Hazard Area & River Corridor General Permit may apply. For further information, contact a Permit Specialist for a Project Review Sheet.

http://dec.vermont.gov/environmental-assistance/permits

State of Vermont
PERMIT AND LICENSE INFORMATION

FEDERAL PERMIT REQUIREMENTS FOR WORK IN WETLANDS

SUMMARY DESCRIPTION OF PERMIT

Permits required for the discharge of dredged or fill material or mechanized land clearing in all waters of the United States, including wetlands, under Section 404 of the Clean Water Act. Impacts subject to Federal review include not only the area of wetland directly filled, but also any inundation or drainage of wetlands caused by the placement of fill or mechanized land clearing.

EXAMPLE OF ACTIVITY

Filling a wetland adjacent to Lake Champlain; construction of a pond in wetland.

CRITERIA FOR JURISDICTION

Projects or activities, which involve the placement of fill, excavation, or mechanized land clearing in jurisdictional wetlands. Certain small projects may be eligible for authorization under abbreviated procedures.

DEFINITION OF "WETLAND": The term "wetland" is defined by Federal regulations to mean "...those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions..." (33 CFR Part 328.3 (b), as published in the November 13, 1986 Federal Register). Wetlands generally include swamps, marshes, bogs and similar areas.

DEFINITION OF "FILL": The term "fill material" is defined by Federal regulations to mean "...any material used for the primary purpose of replacing an aquatic area with dry land or of changing the bottom elevation of a waterbody. The term does not include any pollutant discharged into the water primarily to dispose of waste..." (33 CFR Part 323.2 (b), as published in the November 13, 1986 Federal Register).

INFORMATION REQUIRED

Requires submission of completed application form, vicinity map, site plan and cross-sections of proposed activity. A wetland delineation using the *1987 Corps of Engineers Wetlands Delineation Manual* and *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast Region* is required. The Natural Resources Conservation Service should be contacted for delineation of agricultural lands. Plans should be drawn to scale and include the wetland boundary, dimensions of the proposed work, and extent of wetland encroachment. Waterways and wetlands are vital areas that constitute productive and valuable public resources, the unnecessary alteration or destruction of which is to be discouraged. Therefore, Federal regulations state that filling of these resources shall not be permitted unless the applicant clearly demonstrates the following:

a. that the activity associated with the fill must have direct access or proximity to or be located in the water resources in order to fulfill its basic purpose, and that other site or construction alternatives are not practicable; or

b. if the activity associated with the fill does not have to have direct access to the water resources, you must provide information on the need to place fill in the waterway and/or wetlands and the feasibility of alternative sites or methods to accomplish the objective of the project.

In addition to a and b above, the possibilities for mitigation of any unavoidable damages to the resources must be discussed. If mitigation is possible, it should be included as part of the application. The applicant must submit information that thoroughly and clearly documents the need for the fill, alternatives, and mitigation possibilities.

WEB ADDRESS http://www.nae.usace.army.mil/Missions/Regulatory/

FEES $0 - $100; dependent upon type of permit to be processed.

APPLICATION TIMEFRAME Dependent upon type and complexity of project. Small, non-controversial projects can be processed in 15-90 days; large, controversial projects can take considerably longer.

ADMINISTERING AGENCY

U.S. ARMY CORPS OF ENGINEERS

CONTACT: U.S. Army Corps of Engineers
Vermont Project Office
802-872-2893

ADDRESS: 11 Lincoln St, Room 210
Essex Junction, Vermont 05452

AUTHORITY 33 USC 1344 (Clean Water Act)

APPLICABLE RULES 33 CFR Part 323 as published in the November 13, 1986 Federal Register

APPEAL PROCESS None

State of Vermont
PERMIT AND LICENSE INFORMATION

FEDERAL PERMIT REQUIREMENTS FOR WORK IN RIVERS AND STREAMS

SUMMARY DESCRIPTION OF PERMIT	Permits required for all structures or work beyond the ordinary high-water mark in navigable waters of the United States under Section 10 of the Rivers and Harbors Act. Permits required for the discharge of dredged or fill material or mechanized land clearing in all waters of the United States under Section 404 of the Clean Water Act.
EXAMPLE OF ACTIVITY	Rip-rap river bank below ordinary high water; filling of streambed for bridge abutments.
CRITERIA FOR JURISDICTION	Projects or activities which encroach beyond the ordinary high watermark of the Batten Kill, Black River, Connecticut River, Lamoille River, Missisquoi River, Moose River, Nulhegan River, Nulhegan River - Black Branch, Nulhegan River - East Branch, Nulhegan - Yellow Branch, Ompompanoosuc River, Otter Creek, Paul Stream, Passumpsic River, Passumpsic River - East Branch, Waits River, Wells River, White River, and Winooski River, including (but not limited to) dredging, shoreline stabilization, and water intakes. Projects or activities, which involve the discharge of, dredged or fill material or mechanized clearing beyond the ordinary high-water mark in all other rivers and streams within the State. Certain small projects may be eligible for authorization under abbreviated procedures.
INFORMATION REQUIRED	Requires submission of completed application form, vicinity map, site plan and cross-sections of proposed activity. Plans should be drawn to scale and include the ordinary high-water mark, dimensions of the proposed work, and extent of encroachment beyond the ordinary high water mark.
WEB ADDRESS	http://www.nae.usace.army.mil/Missions/Regulatory/
FEES	$0 - $100; dependent upon type of permit to be processed.
APPLICATION TIMEFRAME	Dependent upon type and complexity of project. Small, non-controversial projects can be processed in 15-90 days; large, controversial projects can take considerably longer.

ADMINISTERING AGENCY	**U.S. ARMY CORPS OF ENGINEERS** **CONTACT:** U.S. Army Corps of Engineers Vermont Project Office 802-872-2893 **ADDRESS:** 11 Lincoln St, Room 210 Essex Junction, Vermont 05452
AUTHORITY	33 USC 403 (Rivers and Harbors Act of 1899) and 33 USC 1344 (Clean Water Act).
APPLICABLE RULES	33 CFR 322-323 as published in the November 13, 1986 Federal Register.
APPEAL PROCESS	None

State of Vermont
PERMIT AND LICENSE INFORMATION

WORK IN A STATE HIGHWAY RIGHT OF WAY

SUMMARY DESCRIPTION OF PERMIT	Prior to performing any work or installing any utility facility within the State highway right-of-way, a Title 19, § 1111 permit is required from the Agency of Transportation.
EXAMPLE OF REGULATED ACTIVITY	Work within the limits of a State highway right-of-way (for example, construction of a driveway, installation of a culvert, excavation of a ditch or re-grading, paving or re-paving) requires a permit from the Agency.
CRITERIA FOR JURISDICTION	A permit is needed for nearly any activity in or directly affecting the highway right-of-way, including (but not necessarily limited to) creation or modification of a driveway, repaving a portion of a driveway within the right-of-way, placement of structures, placement or grading of earthen material, discharge of water, or nearly anything else that would affect the right-of-way. The full scope of this permit process is beyond the scope of the general information handout.
INFORMATION REQUIRED	Includes the applicant's and/or owner's name, address, phone number(s); location and description of the work to be performed; when the work is planned to begin and be completed; if Act 250 or local zoning permit is required; and, if filing for such permits, has the process been initiated. Other information includes a plan or sketch, providing a clear showing of the proposed work, including all appropriate details. Requests for residential access permits are to be submitted to the Agency's District Transportation Administrator.
FEES	A processing fee may be required. The applicant will be responsible for any mitigation improvements needed to the State highway because of the applicant's work; and for any inspection services deemed necessary to ensure the work is performed to State requirements. In the case of a permit for access (driveway), the applicant is also responsible for the land records recording fee, paid to the municipality, to record "Notice of Permit Action".
APPLICATION TIME FRAME	One – two months
ADMINISTERING AGENCY	**AGENCY OF TRANSPORTATION** **CONTACT:** Craig Keller, Chief of Permitting Services Phone: 802-279-1152 Office: 802-828-2653 craig.keller@vermont.gov http://vtrans.vermont.gov/planning/permitting **ADDRESS:** 219 N. Main St. Barre, VT 05641
AUTHORITY	19 V.S.A. § 1111
APPEAL PROCESS	Administrative Hearing, Transportation Board, Superior Court

State of Vermont
PERMIT AND LICENSE INFORMATION

PROTECTION OF HISTORIC SITES UNDER CRITERION 8 OF ACT 250

SUMMARY

The Vermont Division for Historic Preservation is considered under state law (22 V.S.A. Chapter 14) the state's expert on historic and archeological resources. The Division provides District Commissions with comments and the necessary information for them to make a positive finding under the historic sites aspect of Criterion 8. Project review by the Division consists of identifying the project's potential impacts to historic buildings, structures, historic districts, historic landscapes and settings, and known or potential archeological resources. Under 10 V.S.A. Chapter 151 (Act 250), section 6001 (9), the Vermont Advisory Council on Historic Preservation is responsible for providing testimony about the significance of historic and archeological resources.

NOTE: In some cases, an Act 250 project also has federal funding or requires a federal permit. In such cases, the project is also subject to the provisions of Section 106 of the National Historic Preservation Act (see Sheet #101). Compliance with Section 106 generally satisfies the needs of the Act 250 process. However, because of the very specific Section 106 review procedures, satisfying Act 250 may not ensure compliance with Section 106 requirements.

EXAMPLES OF ACTIVITY

Including but not limited to: ground disturbing projects (i.e. subdivisions, golf courses, ski area improvements, radio towers, etc.), whole or partial demolition of buildings or structures, new construction in an historic district or historic landscape, rehabilitation of buildings or structures.

INFORMATION REQUIRED

Copy of USGS topographic map showing project location; detailed project description; site plan, if available; information about past and current land use; clearly labeled photographs of any buildings or structures that are 50 years old or older within the project area and photos of their surroundings and adjacent landscape; building's dates of construction and any significant alterations; building elevations, if rehabilitation of an historic building is proposed. The Division or Advisory Council may require additional information as the review process proceeds. **The review process works best when early planning and consideration of historic and archeological resources allows adequate time for thoughtful and careful decision making, thereby avoiding last minute surprises, tight turnaround times, and delays.**

WEB ADDRESSES

http://accd.vermont.gov/historic-preservation/review-compliance

FEES

None. However, Act 250 applicants may find it necessary to hire qualified consultants such as professional archeologists, professional architectural historians, and architects to assist resource identification and review of potential project effects.

APPLICATION TIME FRAME

Depends on size and complexity of project and degree of potential impacts. Consultation with Division as early as possible in planning stage will ensure a more efficient process and may reduce potential development conflicts with resources through a “least impact” project design. If field inspection by Division staff and Advisory Council review are necessary, process may require several months. Field inspections (or archeological field investigations) cannot be undertaken under conditions of frozen ground or snow cover. This seasonal limitation to field activities requires appropriate, advanced planning during the review process to take maximum advantage of frost-free/snow free ground (mid-late April to early-mid November).

ADMINISTERING AGENCY

AGENCY OF COMMERCE AND COMMUNITY DEVELOPMENT
VERMONT DIVISION FOR HISTORIC PRESERVATION
Serving as the STATE HISTORIC PRESERVATION OFFICE

CONTACT: Jamie Duggan, Historic Preservation Review Coordinator
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Montpelier, Vermont 05620-0501
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AUTHORITY

10 VSA Chapter 151 (Act 250);
22 VSA Chapter 14 (VT Historic Preservation Act).

APPEAL PROCESS

See Sheet #47 relating to Act 250

State of Vermont
PERMIT AND LICENSE INFORMATION

OBSTRUCTING STREAMS

SUMMARY DESCRIPTION OF PERMIT
Commissioner approval required for permanent or temporary stream obstructions to fish passage. Permit form is a letter from Commissioner authorizing obstruction.

EXAMPLE OF REGULATED ACTIVITY
Dam or weir repair and construction; culvert installation.

CRITERIA FOR JURISDICTION
Impact of proposed activity on fish passage.

INFORMATION REQUIRED
Description and location of proposed activity, name of waterbody.

FEES
None.

WEB ADDRESS
http://vtfishandwildlife.com/conserve/development-review

APPLICATION TIME FRAME
30-60 days from receipt of request. Review may include on-site inspection by fisheries biologist.

ADMINISTERING AGENCY
VERMONT FISH & WILDLIFE DEPARTMENT

CONTACT: Local fisheries biologist in district office closest to site.

AUTHORITY
10 V.S.A. Section 4607

APPEAL PROCESS
None

OTHER PERMITS
Ponds Fact Sheet #32.1, Dams Sheet #45, Stream Alteration Sheet #32, Water Quality Certificate Sheet #27, Wetlands Sheet #29, Corps. of Engineer Sheets #98 & 99.

Appendix I

Alternative Funding Sources

Dam Rehabilitation Alternative

Historic Preservation Grants Frequently Asked Questions

Do I qualify for a Historic Preservation Grant?
Properties owned by non-profit organizations or municipalities are eligible for funding through the state grant program. A building must also be either listed or determined eligible for listing in the *National Register of Historic Places* to qualify. You may contact the Division for Historic Preservation to learn if your building is listed or has been determined eligible for listing. Privately owned businesses or homes are not eligible for funding.

How much funding is available?
Grants of up to $20,000 are available on a 1 to 1 matching basis. This is a reimbursement program, which means that if you are awarded a grant, you are responsible for paying for the full amount of the project and the State will then reimburse you once the project and required paperwork are complete. Annually, and pending legislative approval, the program has $200,000 available in grant funds.

Can I start my project before I get a grant?
No. You may not apply for funding to support projects that have already been completed or are in progress. If your project is large with many components, you may be able to do work on your building before you get a grant, if the portion of the project to be funded with a grant has NOT started.

What work is eligible for funding?
Projects to repair and/or restore historic building features are eligible. Work must meet the Secretary of the Interior's *Standards for Rehabilitation* to qualify for funding. This could include but is not limited to:

- Work on a failed structural component, such as the building's frame, foundation or roof;
- Repairs to damaged or deteriorated components of the historic building, such as windows, doors, porches, and siding; and
- Preservation or restoration of significant historic features of a building, including historic plaster or decorative painting restoration

Ineligible work includes new construction, additions, electrical, plumbing or heating projects and weatherization or code improvements. Work that is generally considered maintenance such as cleaning or painting, will not be funded. Planning projects are also not eligible for funding.

What information must be provided with an application?
In addition to completing a Historic Preservation Application, all applicants must provide the following information to the Division for Historic Preservation in order to be considered for grant funding:

- Estimate – a detailed, written estimate from a qualified contractor for your project
- Photographs – digital photographs documenting your building and the issues you are trying to resolve
- Proof of non-profit status

When can I apply?
Applications for funding are generally made available during August annually and the deadline for applications is the first Monday of October each year. To receive notification regarding the next round of Grants and be added to our mailing list, contact Caitlin Corkins at 802-828-3047.

Caitlin Corkins, Tax Credits & Grants Coordinator 802-828-3047

Dam Removal Alternative

https://dec.vermont.gov/watershed/rivers/streamflow-protection/dam-removal#:~:text=Dam%20removal%20has%20in%20recent,financial%20burdens%20on%20their%20owners.

https://dec.vermont.gov/sites/dec/files/wsm/rivers/docs/drw_funding.pdf

https://www.ctriver.org/our-work/reconnecting-habitat-for-fish/

https://www.americanrivers.org/river-restoration-funding-sources/

https://www.federalgrants.com/National-Fish-Passage-Program-19005.html

https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/

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