ALTERNATIVES EVALUATION

SWEET POND DAM

VT Dam #90.01
Town of Guilford, Vermont

Prepared for:
Vermont Department of Forests, Parks and Recreation

Prepared by:

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SWEET POND DAM
ALTERNATIVES ANALYSIS

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I. EXECUTIVE SUMMARY

This Alternatives Evaluation Report of Sweet Pond Dam in Guilford, Vermont presents five alternatives to address the safety issues that currently exist at the dam. The report provides an overview of recent inspections, a summary of the hydrologic and hydraulic analysis of the dam, a dam breach analysis summary, and a review of a previous engineering evaluation outlining rehabilitation of the dam. This information was utilized to develop the five alternatives presented within. Benefits and drawbacks of each alternative are presented, as are potential costs.

Sweet Pond Dam is classified as a Small sized structure with a High Hazard Potential (Class I). The dam has been determined to be in Fair to Poor condition, with the following deficiencies:

- Significant seepage under the foundation of the dam.
- Significant leakage through the dam.
- Significant cracking of the upstream face of the dam.
- Some bulging in the dry-laid stone masonry downstream face of the dam.

In the Spring of 2011, Sweet Pond was drained due to public safety concerns. Since that time, the State of Vermont's Department of Forests, Parks and Recreation has maintained the dam and Sweet Pond in an empty state by keeping the low level drain fully open.

DuBois & King, Inc. (D&K) has identified and evaluated the following alternatives to address the safety issues at Sweet Pond Dam:

- No action
- Rehabilitation of Existing Dam
- Construction of New Dam
- Rehabilitation of Existing Dam at Lower Height
- Dam Removal

Section IX of this report discusses each alternative in detail, providing potential costs and identifying the benefits and drawbacks for each alternative. Section X provides a summary and comparison of the alternatives.

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II. INTRODUCTION

A. Purpose

The purpose of this investigation was to inspect and evaluate the present condition of the dam and appurtenant structures, as well as to review historical information about the dam. This information was used to identify various alternatives to address the existing safety issues at Sweet Pond Dam.

B. Objective

The objective of this report is to identify alternatives that address the existing safety issues of Sweet Pond Dam, as well as to provide preliminary opinions of probable costs associated with each alternative. This information will be used by Forest, Parks, and Recreation (FP&R) to determine how best to address the safety issues at Sweet Pond Dam.

C. Authority

The ***State of Vermont's Department of Forest, Parks, and Recreation*** retained ***DuBois & King, Inc.*** to perform a visual inspection and develop alternatives for the dam at the ***Sweet Pond*** in ***Guildford, Vermont.*** This inspection and report were performed in accordance with 10 VSA 1105.

III. PROJECT DESCRIPTION

A. Background

The dam is owned by the State of Vermont, and the pond was a popular recreation area until it was drained in the spring of 2011 due to public safety concerns. FP&R has contracted D&K to conduct an engineering study in order to identify various alternative approaches to resolve the dam's safety issues before identifying and implementing a preferred approach.

B. Description of Dam and Watershed

Sweet Pond dam is an earth-filled, dry-laid stone masonry and concrete dam that is located in Guilford, Vermont. The existing structure was constructed in 1928, and is

approximately 20 feet in height at its maximum, and 77 feet in length. The upstream face and crest of the dam are concrete, and the downstream face is dry-laid stone masonry. Repairs were made to the dam from 1987 to 1989. The dam has a history of excessive uncontrolled seepage. A site location plan, and existing conditions site plan are shown in Figures 1 and 2, respectively.

Sweet Pond, impounded by the dam, comprises an area of about 18 acres. The dam and Sweet Pond are located in Sweet Pond State Park. The Pond and surrounding hiking trails are a popular recreational area for local residents and visitors to the region.

IV. PREVIOUS REPORTS

A. Engineering Evaluation of Sweet Pond Dam

In May of 2002, GEI Consultants, Inc. conducted an engineering evaluation of Sweet Pond Dam. Field investigations conducted as part of the 2002 evaluation noted excessive seepage and leakage through the upstream concrete face. Internal erosion of the embankment soils was also noted. Seepage analyses indicated that the existing structure does not meet stability criteria for the ice and design flood loading conditions. As such, the evaluation recommended the construction of a concrete cutoff wall along the upstream face of the dam. A cutoff wall is a concrete wall integrated to the existing upstream face of the dam that is constructed to extend deeper than the existing dam, in order to "cut off" the seepage paths that exist through the existing dam face and weathered rock zone underneath the dam. Footings for the new cutoff wall were recommended to be cast on "more competent" bedrock beneath the existing weathered rock zone underneath the dam. In addition to the cutoff wall, recommendations also included installing a new concrete slab on the crest of the dam, scour protection downstream of the dam, and rehabilitation work to the existing downstream stone face. The 2002 engineering evaluation is included in Appendix A.

B. Summary of VT DEC Inspection

In August of 2010, engineers with the State of Vermont's Dam Safety Division conducted a periodic inspection of Sweet Pond Dam in Guilford. Excessive leakage and seepage was noted through the dam, and the overall condition of the dam was determined to be poor, due to the excessive seepage and stability concerns. A number of recommendations were included in the inspection summary memorandum, which is

included in Appendix B. The details of the inspection and the deficiencies observed are discussed in more detail in Section VIII.

V. VISUAL SITE INSPECTION

A. Topographic Survey

A topographic survey was conducted by D&K on the dam and surrounding areas on July 18, 2011. The survey included major points along the existing dam structure, as well as multiple cross-sections of the drained pond upstream of the dam and a cross-section of the area downstream of the dam. Sediment depths were also measured and recorded along the cross-sections upstream of the dam. This information was amended by previous survey information collected by D&K at the site, as well as information from the GEI survey conducted in 2002.

B. Site Inspection

A thorough site inspection was also conducted by D&K on July 18, 2011. The inspection included the drained pond, the dam structure, and the downstream area of the dam. The upstream face, crest, spillway, inlet structure, downstream face, and inlet drain were also inspected. A complete inspection report is attached in Appendix C. The dam was found to be in generally fair condition; however, indications of seepage were not present due to the drained condition of the pond.

VI. HYDROLOGIC AND HYDRAULIC ANALYSIS

A. Overview

A hydrologic and hydraulic analysis was conducted by D&K for Sweet Pond Dam in March of 2011. The following provides a summary of the analyses. The complete report is attached in Appendix D.

B. Hydrologic Analysis

A rainfall-runoff model for the Sweet Pond Dam watershed was prepared using the HydroCad computer program. The model was used to calculate the volume and timing of flows into Sweet Pond Dam during the 100-year and the ½ PMF (probable maximum flood) conditions. It was then used to evaluate the hydraulic capacity of the existing dam.

2-year, 10-year, 25-year, and 50-year inflows were also computed. The results are summarized in Table 1 below.

Table 1 - Summary of Hydrologic Analysis

Event	24-hr Rainfall Depth (in)	Peak Inflow to Sweet Pond Dam (cfs)	Unit Discharge (cfs/sq. mi.)
100-year	6.78	669	619
½ PMF	15.00	2,580	2,035
Full PMF	30.00	6,170	5,713

C. Hydraulic Analysis- Spillway Capacity

The inflows computed for Sweet Pond Dam in the Hydrologic Analysis were then routed through the existing spillway using HydroCad. The existing spillway was modeled as a 17-foot broad-crested weir discharging to a steep concrete and rock lined channel. The crest of the spillway was set at elevation 960.5 feet, which corresponds to the normal pool elevation. The results are summarized in Table 2 below. A negative value in the "freeboard" column indicates the dam is overtopped.

Table 2 - Summary of Hydraulic Analysis

Condition	Storm Event	Top of Dam Elev. (ft)	Normal Pool Elev. (ft)	Inflow (cfs)	Outflow (cfs)	Peak WSEL (ft)	Freeboard (ft)
Existing	17-foot concrete spillway, crest elevation at 960.5 feet.						
	Q-100	962.0	960.5	669	380	93.1	-1.1
	½ PMF	962.0	960.5	2,580	2,035	966.2	-4.2
	Full PMF	962.0	960.5	6,170	5,438	969.8	-7.8

D. Tropical Storm Irene Performance

Sweet Pond was drained when Tropical Storm Irene passed over the site in late August 2011. The low level outlet was open at the start of the storm, though was reportedly at

least partially blocked during the event. The pond filled and water flowed several inches deep through the spillway.

The volume of the pond below the spillway is approximately 100 acre-feet (32 million gallons). That volume corresponds to the runoff from approximately 5 inches of rainfall. Estimates of rainfall depth around the State during Irene are typically in the 5 - 8 inch range, suggesting that the vast majority of the Irene rainfall at the site (assuming the actual rainfall depth is similar to the depth reported elsewhere) went to refilling the pond.

Using the rainfall-runoff model developed for the previously-completed hydrologic analysis, a rainfall depth of 5.5 inches would result in several inches of depth in the Sweet Pond Dam spillway, which is what was reported during Irene. Had the pond been full with the arrival of that 5.5 inches of rainfall, the depth of flow would have been approximately five inches over the entire crest of the dam, which would have created significant impacts downstream of the dam.

VII. DAM BREACH ANALYSIS

A. Overview

A dam breach analysis of Sweet Pond Dam was conducted in March 2011 by D&K. The analysis was performed as an integral component of the Emergency Action Plan as well as to provide the technical basis for confirming the dam's hazard classification. Both sunny-day and storm-day hypothetical dam failures were evaluated. Each are described briefly below. The Dam Breach Analysis is attached in Appendix E.

B. Dam Breach Results

- Sunny-Day

  The results of the sunny-day breach are summarized below:
  - During a sunny-day breach, the peak discharge released from the reservoir to the downstream channel was determined to be 2,635 cfs.
  - The peak sunny-day breach flow is reduced by just over 50% to 1,273 cfs by the time it reaches the downstream study limit (the Vermont-Massachusetts State line) approximately 0.9 hours after the breach.

- Three homes are impacted by the sunny-day breach. Depths of inundation range from 0.6 to 3.7 feet.
- All seven structures (culverts) over Keets Brook are overtopped by 0.4 to 2.0 feet. All roads are Class 2 or 3 Town highways, and the duration of overtopping ranges from 0.5 to 1.8 hours.

- Storm-Day

  The results of the storm-day breach are summarized below:
  - During a storm-day breach, the peak discharge released from the reservoir to the downstream channel was determined to be 5,830 cfs.
  - The peak storm-day breach flow is reduced by just over 50% to 2,960 cfs by the time it reaches the downstream study limit (the Vermont-Massachusetts State line) approximately 0.7 hours after the breach.
  - Six homes are impacted by the storm-day breach. Depths of inundation range from 0.6 to 5.4 feet.
  - All seven structures (culverts) over Keets Brook are overtopped by 3.0 to 5.0 feet. All roads are Class 2 or 3 Town highways, and the duration of overtopping ranges from 1 to 3 hours.

C. Dam Hazard Classification

At the time of the Dam Breach Analysis, Sweet Pond Dam was classified as a Class 2 Significant Hazard structure. Based on the results of the breach analysis, and specifically the three and six homes that are inundated during the sunny-day and storm-day respectively, and the overtopping of multiple Class 2 and Class 3 Town Highways, the State of Vermont Dam Safety Section reclassified the dam as a Class 1 High Hazard Structure.

VIII. SUMMARY OF DEFICIENCIES

A. DuBois and King Inspection

D&K conducted a visual inspection of Sweet Pond Dam on July 18, 2011, as discussed above and presented in Appendix C. The following summarizes the deficiencies noted during the inspection.

- Dam in generally fair condition.
- Upstream face shows significant cracking.
- Previous crack repairs (filler) failing.
- Downstream face dry-laid stone, some bulging noted.
- Crest and Weir in generally satisfactory condition, some cracking noted.

It should be noted that Sweet Pond was drained during the inspection performed by D&K. Any evidence of seepage was therefore not present. The inspection documents are included in Appendix C.

B. State of Vermont Dam Safety Inspection

On June 7, 2010, Stephen Bushman, P.E., and Shawn Thompson from the State of Vermont's Dam Safety Section conducted an inspection of the Sweet Pond Dam. The overall condition of the dam as reported during the 2010 inspection was reported as "poor due to the continued deterioration of the dam, documented excessive seepage, and stability concerns." The following summarizes recommendations made as part of the 2010 inspection.

- Dam should be included in FP&R's capital plan for major infrastructure repairs, or should be considered for removal.
- 2002 Stability Analysis determined the dam does not meet stability criteria for ice and design flood loading conditions.
- Excessive leakage through the upstream concrete wall has caused some internal erosion of the dam. Seepage was noted though the concrete and weathered bedrock foundation. Continued leakage and vegetation growth are destabilizing the dam.

Historic documentation of Sweet Pond Dam, including the 2010 inspection report summary, is included in Appendix B.

C. Summary of Inspections

As discussed above, the conditions during the inspection of the Sweet Pond Dam and Sweet Pond varied significantly between the 2010 and 2011 inspections. During the 2010 inspection, the pond was filled and significant seepage was evident through both the face of the dam and the weathered bedrock foundation. As the pond was drained prior to the 2011 inspection, there was no direct evidence of active seepage. However, due to the

drained condition of the pond, the upstream face of the dam was visible during the 2011 inspection. The upstream face showed significant cracking, and failing repairs of previous cracks were also evident. These observations concur with the conclusions drawn during the 2010 inspection that significant seepage was occurring through the upstream face of the dam. In summary, the major deficiencies noted in the dam are as follows.

- Significant seepage through both the upstream face and weathered bedrock foundation.
- Significant cracking in the upstream face and crest of the dam.
- Some bowing or bulging noted on the dry-laid masonry downstream face of the dam.

These deficiencies are significant, and warrant consideration of dam rehabilitation or dam removal to reduce the possibility of a failure of Sweet Pond Dam.

IX. REMEDIATION ALTERNATIVES

The principal objective of this study is to identify remediation measures that provide for public safety at and downstream of Sweet Pond while maintaining the current aesthetic, historic character and recreational opportunities. Deficiencies identified over the course of several years suggest that Sweet Pond Dam can not do so under the current existing conditions. To mitigate these deficiencies the following remediation alternatives are presented:

Alternative 1: No Action – Existing Dam to Remain in Place
Alternative 2: Rehabilitation of Existing Dam
Alternative 3: New Dam in Current or Upstream Location
Alternative 4: Rehabilitation of Existing Dam at Lower Height
Alternative 5: Dam Removal

Each of these alternatives is discussed in further detail below.

A. Alternative 1 – No Action - Existing Dam to Remain in Place

Under the existing conditions Sweet Pond Dam is not suitable to impound a full pond. This determination was made by the FP&R with the assistance and support of the Vermont Dam Safety Section. Subsequently, the pond was dewatered by opening the

low level outlet at the dam. It should also be noted that Dam Safety does have the statutory authority to take legal action against owners of dams it has deemed unsafe.

If no action is taken by either State, Municipal or non-government sponsors, the dam will continue to deteriorate and regulators from Vermont Dam Safety will not permit refilling of the pond. Further, because the low level outlet is relatively small and prone to clogging, it is likely that Dam Safety will require that the dam itself be breached to prevent temporary refilling of the pond during storm events.

Since this alternative does not satisfy the principal objective of this study D&K recommends that non action be eliminated from further consideration.

B. Alternative 2 – Rehabilitation of Existing Dam

A conceptual rehabilitation design concept was presented by the GEI Consultants, Inc. in their Engineering Evaluation of Sweet Pond Dam, submitted to the VANR Department of Environmental Conservation, Dam Safety Section, dated May 2002. D&K has done an extensive review of the GEI design, and it is our professional opinion that the design concept remains a sound and cost-effective approach to rehabilitating this dam.

The design concept includes a concrete cutoff wall immediately upstream of the existing dam, a new concrete slab over the crest, overtopping protection, and repair of the stone masonry. It is D&K's opinion that one component of the previous conceptual design – reconstruction of the wet well – can be eliminated from the rehabilitation considered in Alternative 2. The wet well is the chamber on the upstream face through which the gate valve is accessed. The upstream embankment can instead be regraded as part of the rehabilitation to eliminate the need for and expense of a wet well. A typical cross-section of the proposed rehabilitation alternative is included in Figure 3.

Each primary component of the rehabilitation design concept is described below.

Primary Components

Concrete Cutoff Wall. A reinforced concrete cutoff wall will be cast directly against the upstream face of the dam. This cutoff wall will extend from the existing crest downward into the bedrock foundation. By "socketing" the cutoff wall into solid bedrock, the seepage under the dam through weathered bedrock will be decreased significantly and the structural stability will be greatly increased. The 1989 repairs to the dam, while effective

in many regards, did not adequately address the seepage through the weathered bedrock as this proposed cutoff wall is designed to do.

Concrete Crest Cap. The concrete slab across the entire crest of the dam is deteriorated and requires replacement. Additionally, there are voids under the slab in several locations. The slab should be replaced with a new reinforced concrete slab. The embankment material below the new slab would be further protected by the installation of geotextile fabric and crushed stone to reduce the potential for internal erosion and support the new concrete slab. Removal and replacement of the slab will also facilitate a thorough inspection of the embankment under the existing slab and allow for other remedial measures.

Overtopping Protection. Hydrologic and hydraulic analyses conducted by the VANR suggest that during the Spillway Design Flood (SDF), ½ PMF for a Significant Hazard Dam, would result in approximately 3 feet of overtopping. During the D&K 2011 inspection, scour at the downstream toe of the dam was evident. Further overtopping would promote additional scour which could eventually undermine the stone masonry. Scour protection should also be placed to protect the abutments at the crest elevation, most notably to prevent erosion of the adjacent roadway.

Stone Masonry Repair. The GEI report indicated that the stone masonry face was showing signs of deterioration and movement. This was confirmed during the 2011 D&K inspection, since the face was dry and a close inspection of the stone masonry was achievable. D&K concurs that complete re-pointing of the face is not advisable, due to the fact that it would inhibit drainage of the embankment soils. However, re-pointing of the upper portions should be done to provide for additional stability by preventing the stones from movement while subject to freeze/thaw cycles. To provide for further stability, the old sluiceway should be filled with concrete to improve support of the overlying embankment soils.

Cost

The approximate cost of rehabilitating the dam is $330,000, which includes $270,000 for construction and $60,000 for engineering and permitting. Maintenance costs are estimated to be on the order of $5,000 - $10,000 per year. These costs would be applied to such activities as clearing unwanted vegetation, operating the gate, and addressing spot repairs to masonry and concrete as needed.

Benefits and Drawbacks

The benefits of Rehabilitating the Existing Dam include the following:

- With the implementation of this rehabilitation design concept, the dam will retain its current aesthetics and historic character. The rehabilitated dam will not look appreciably different than the current structure. The casual observer would likely not notice a difference in the dam's overall appearance between the pre and post rehabilitation.
- The rehabilitation will allow for a full impoundment behind the dam. All recreational opportunities that were available previous to the draining of the pond will be restored.
- Public safety will be improved over the pre-drained condition. The rehabilitated dam will satisfy all modern dam safety standards.

Drawbacks of the Dam Removal Alternative include the following:

- While the rehabilitated structure will be essentially new, annual maintenance will be required. This maintenance is necessary to ensure that the dam remains in satisfactory condition.
- As with all engineered infrastructure, this design concept has a design life, which can be estimated at approximately 50 years. Beyond this timeframe, the structure will likely require further rehabilitation efforts. As with annual maintenance costs, the owner is urged to plan and budget for future rehabilitation costs.

C. Alternative 3 – New Dam Construction

This alternative would include removing the entire existing dam and rebuilding it either in its original location or a location equally suitable to impound the pond at its historic levels. Under this alternative the design concept would entail a new concrete gravity structure "socketed" into competent bedrock. The length and height of the dam would approximately match the existing structure. A primary spillway and low level outlet would also be incorporated into the design. Additional safety features such as safety fencing and catwalks would be required. This design would function as the rehabilitated design concept. A conceptual site plan and typical dam section of Alternative 3 are shown in Figure 4.

Cost

The cost of a new dam is approximately $613,000, which includes $511,000 for construction and $120,000 for engineering and permitting. Maintenance costs would be on the order of $5,000 - $7,000 per year on average, which would be applied to such activities as clearing unwanted vegetation, operating the gate, and spot repairs to concrete as required as the structure ages.

Benefits and Drawbacks

The benefits of a New Dam are largely the same as with the rehabilitation alternative. The major benefits include:

- A new dam will allow for a full impoundment behind the dam and therefore all recreational opportunities that were available previous to the draining of the pond will be restored.
- Public safety will be improved over the pre-drained condition. A new dam will satisfy all modern dam safety standards.

Drawbacks of the New Dam Alternative include the following:

- A new dam will not retain the current aesthetics and historic character of the existing dam. A stone masonry façade could be added to the downstream face for an additional cost of approximately $ 30,000.
- As part of the permitting process, mitigation for the loss of an historic structure may be required. This typically takes the form of detailed documentation of the structure before and during demolition.
- While the new dam alternative will be 'new', annual maintenance will still be required. This maintenance is necessary to ensure that the dam remains in satisfactory condition.
- As with all engineered infrastructure this design concept has a design life, which can be estimated at approximately 75 years. Beyond this timeframe, the structure will likely need further rehabilitation efforts. As with annual maintenance costs, the owner is urged to plan and budget for future rehabilitation costs.

D. Alternative 4 – Rehabilitate Existing Dam at Lower Height

This alternative would include removing the upper portion of the existing dam leaving a shorter structure in place, rehabilitating the remaining portion of the dam, removing accumulated sediment immediately upstream of the dam, and allowing vegetation on the exposed portion of the pond bottom to naturally redevelop. Each primary component is described below.

Primary Components

Remove Upper Portion of the Dam. The center spillway and a significant portion of the dam between abutments would be lowered. The intent would be to reduce the height of the dam and the volume of stored water enough that were it to catastrophically fail, downstream damages would be greatly reduced. It is likely that reducing the dam height by half (from eight to four feet) would be necessary, though an additional hydraulic analysis would be required to confirm the exact height. Lowering only the spillway section would not be adequate because there would still be an unacceptable increase in water depth upstream of the dam (relative to downstream) during the design storm event.

Rehabilitate the Dam. The remaining dam, though shorter than the existing dam, will still need to be rehabilitated to meet current dam safety standards. As described in the Alternative No. 2, primary measures include a concrete cutoff wall immediately upstream of the existing dam, a new concrete slab over the crest, overtopping protection, and repair of the stone masonry.

Removal of Accumulated Sediments. Sediment deposited within approximately 100 feet upstream of the dam would be excavated and removed from the site. The objective would be to increase the depth of pond for improved swimming, aesthetics, and water clarity. The depth of excavation would be up to approximately 3', corresponding to the depth of accumulated sediment measured with sediment probes.

Samples of the sediment were collected and tested in November 2011 for presence of various contaminants. The concentration of Arsenic exceeded the threshold deemed safe for use in residential and commercial settings. Thus, the excavated material would need to be disposed of in a location and manner suitable for contaminated soils.

Passively Re-vegetate the Former Impoundment. The exposed pond bottom would be left to naturally re-vegetate. Past experience with dam removals has shown that a robust

native seed bank is typically present in the soils, and re-vegetation of a hearty stand of grasses and shrubs is common within a year.

Cost

The approximate cost of rehabilitating the dam at a lower height is $330,000, which includes $270,000 for construction and $60,000 for engineering and permitting. Maintenance costs would be on the order of $5,000 - $10,000 per year on average, which would be applied to such activities as clearing unwanted vegetation, operating the gate, and spot repairs when needed to masonry and concrete. These costs are the same as the cost of full rehabilitation. There would be marginally lower cost associated with a shorter concrete cutoff wall, but that savings would be offset by the costs associated with carefully removing and disposing of the upper portion of the dam and dredging upstream to create a deeper pool.

Benefits and Drawbacks

Unlike the other alternatives, the Lower Dam Alternative is very much a compromise approach, and this is reflected in the benefits and drawbacks. For instance, this alternative preserves some recreational value at the site (which is a benefit), but also clearly alters the pond in detrimental ways relative to existing conditions. Thus, some criteria against which the alternative is evaluated are discussed below as both a benefit and a drawback.

The benefits of the Lower Dam Alternative include the following:

- Reduction of Downstream Hazards. The risk of dam failure and resulting downstream impacts, including the inundation of multiple homes and the prolonged overtopping of municipal roads, would be significantly reduced.
- Preservation of Historic Structure. While this alternative would significantly alter the dam, the historic structure would remain as a functioning dam.
- Preservation of Some Ponded Water. Ponded water would remain at the dam site, primarily for its aesthetic value, and to a lesser extent for recreational value.
- Recreation Value. The primary recreational use of the site – hiking the circumferential trail around the pond – would be changed with the significantly smaller pond, but even the smaller dam would remain an attraction and a focal point of the park. In the near-term, the progressive

natural reclamation of the exposed pond bottom would provide a visual interest and attraction along the route. As the vegetation matures and views of the former pond are lost, however, the value of the recreational trail may be diminished. While not presently included as components of this alternative, modifications to the existing trail, such as new vista locations or construction of boardwalk segments across wet portions of the former pond bottom, could be added to the project.

Drawbacks of Partial Dam Removal include the following:

- Significant Reduction of the Size of the Pond. Reducing the height of dam by half would result in an estimated 75% reduction in pond surface area and volume. The aesthetic value of ponded water – including the stillness and reflective qualities – would be lost at many locations along the current perimeter, particularly in the upper 2/3 of the pond. The reduced depth may allow adequate sunlight to reach the pond bottom to trigger an increase in submerged aquatic vegetation.
- Recreation Value. The reduced pond area and depth would significantly reduce the attractiveness of the site for boating. On the hiking trail, vista locations would need to be relocated to the new water edge, and the vistas would lack the relatively long sight lines over the existing pond. The trail could certainly remain, but without the draw of the larger pond, some may see it as simply a common walk in the Vermont woods.

E. Alternative 5 – Dam Removal

This alternative would include removing all or a significant portion of the dam, spreading sediments that were deposited behind the structure, stabilizing and planting the disturbed area, and allowing the upstream stream channel and vegetation to naturally redevelop. Each primary component is described below. A landscape rendering showing the site without the dam is shown in Figure 5.

Primary Components

Remove the Dam. The center spillway and some portion of the abutments would be removed. The natural bankfull channel width is approximately 14 feet, and to minimize impact on storm flows and sediment transport, that should be considered a minimum length of dam to be fully removed. Preferably, a portion of dam 1.5 to 2.0 times natural

bankfull width (21 - 28 feet) would be removed to ensure that any remaining portion of the dam has no impact on flows or channel stability. Small portions of the abutments could remain for historic preservation purposes, and possibly these remnants could serve as abutments for a future longer pedestrian bridge. The stone and concrete removed from the dam would be disposed of off-site.

Spread Near-Dam Sediments. Observations of the site indicate that there is a wedge of sediment against the upstream face of the dam. Sediment probes indicated that there is fine sediment to a depth of approximately three feet on much of the pond bottom from the dam to a point approximately 500 feet upstream.

Sediment deposited against the dam and for a distance of approximately 50 feet would be removed as part of the dam removal and channel restoration work. Additional material upstream would be left in place. The removed material would be spread on-site, likely on the former pond bottom in what will be the overbank or floodplain of the stream. Off-site removal is also possible if a demand for the material is identified to justify the trucking cost.

Samples of the sediment were collected and tested in November 2011 for presence of various contaminants. The concentration of Arsenic exceeded the threshold deemed safe for use in residential and commercial settings. Thus, if the removed material is to be trucked off-site, its use is limited. It is acceptable to use it in a location where it will be covered by clean soil or in a landfill as daily cover.

Stabilize the Immediate Area. The disturbed area immediately surrounding the removed dam would be graded, seeded, and mulched. This includes active reconstruction of the stream channel in the footprint of the dam and for a distance of approximately 50 feet upstream and down. Additional riparian planting would also be installed in this area.

Passively Re-vegetate the Former Impoundment. The exposed pond bottom would be left to naturally re-vegetate. Past experience with dam removals has shown that a robust native seed bank is typically present in the soils, and re-vegetation of a hearty stand of grasses and shrubs within a year of removal is common.

Passively Restore the Stream Channel. The stream channel above the dam would be left to naturally develop. Given the narrow, relatively confined valley upstream, the alignment of the channel is relatively fixed, and the channel is expected to return to its historic path and expose the historic channel bed material within a year of dam removal if

not sooner. Development of the channel would be monitored, and if it appears that a stable channel is not developing as anticipated (as has been the case at sites where the historic channel bed material was removed during initial dam construction or later dredging), active channel restoration would be used to construct a stable channel where needed.

Replacement Pedestrian Bridge. The pedestrian bridge would be replaced at the same location to maintain the functionality of the existing trail system. The bridge could bear on the outer portions of the dam that will remain in place, and span the 21' – 28' portion that has been removed.

Cost

The approximate cost of removing the dam is $204,000, which includes $161,000 in construction costs and $43,000 for historic documentation study, design, and permitting. The construction cost ($161,000) includes a $40,000 allowance for a replacement pedestrian bridge and a $22,000 allowance for active channel restoration should it be needed. Maintenance costs for the dam would be eliminated, but there would still be minor costs on the order of $1000 per year associated with maintaining the replacement foot bridge.

Benefits and Drawbacks

The benefits of the Dam Removal include the following:

- Elimination of Future Repair and Maintenance Costs. All future dam reconstruction and long-term maintenance costs would be eliminated.
- Elimination of Downstream Hazards. The risk of dam failure would be eliminated, and with it the risk of associated flood damages due to a dam breach at the several homes and municipal roads that would be inundated during a dam breach.
- Restoration of the Natural Stream and Habitat. Removing the dam would restore approximately 1.5 miles of free-flowing stream and reduce the habitat fragmentation the dam creates.
- Wildlife Habitat. The exposed pond area and developing riparian zone may provide increased habitat value for some terrestrial and aquatic organisms. The improvements for some species comes at the expense of

others that are better suited to the impounded condition, so this is both a benefit and a drawback.

- Low Cost. Relative to repair or replacement options, dam removal is a lower cost alternative. Further, there are ecosystem restoration grants available from State, Federal, or private organizations that might be available to offset some portion of the removal cost. These are competitive grants, and thus such funding is not guaranteed.

Drawbacks of the Dam Removal Alternative include the following:

- Loss of Pond Aesthetic. The aesthetic value of ponded water – including the stillness and reflective qualities – would be lost. The aesthetic of a flowing stream that would replace it may also have public value, but it potentially may not be an equal trade-off.
- Loss or Significant Alteration of a Historic Structure. The dam has historic value to some, and removing it may be perceived as a loss. Portions of the abutments can remain as a reminder of the site's history, but from a historic preservation perspective, that is certainly not equivalent to the continued presence and function of the dam.
- Wildlife Habitat. Draining the pond eliminates the lake habitat and is a detriment to wildlife including certain fish species that favor such environments. The harm to some species is a benefit to others, so this is both a benefit and a drawback.
- Recreation Value. The primary recreational use of the site – hiking the circumferential trail around the pond – would be undeniably changed without the presence of the pond. In the near-term, the progressive natural reclamation of the former pond would provide a visual interest and attraction along the route. As the vegetation matures and evidence of the pond is lost, however, the value of the recreational trail may be diminished. While not presently included as components of the Dam Removal Alternative, trail amenities such as segments of boardwalk over portions of the recovering pond that are developing as wetlands, could be added to the project to offset loss of recreational value.

X. SUMMARY

The intent of this report and appendices was to provide FP&R and all subsequent stakeholders with alternatives to address the current deficiencies at Sweet Pond Dam. A summary of the assessment is presented below.

A. Summary

Sweet Pond dam was originally constructed in 1928 and was rehabilitated in the late 1980's due to concerns over seepage and dam stability. An engineering investigation was conducted by VANR Dam Safety in 2002 which noted continuing concerns with seepage and stability. Rehabilitation measures were identified but were not implemented at that time. Updated inspections have occurred annually since 2007. In March 2011, a Dam Breech Analysis was performed and the dam was re-classified as a Class 1 High Hazard Structure. Currently, Sweet Pond Dam is considered to be in poor condition and the impoundment has been drained due to concerns regarding the structural integrity of the dam.

The FP&R retained D&K to provide additional analyses with the primary objective of determining the viability of a dam in this location and the necessary considerations for remedial action. Through this analysis, D&K has identified and considered 5 remediation alternatives. These alternatives range from removing and replacing the dam to permanent removal of the dam altogether.

B. Summary of Alternatives

Each alternative considered was evaluated against criterion set forth by FP&R. The evaluation criteria for each alternative were as follows:

- Cost
- Aesthetics
- Recreational Opportunities
- Historic Character
- Public Safety
- Public Acceptance

The evaluation of each criterion was approached on an engineering basis. Due to the subjective nature of some of these criteria, D&K's evaluation considered whether these subjective criteria can retain or match the existing condition. The exception is Cost,

where an estimated value is placed on each Alternative. A summary of these criteria for each alternative is presented in Table 3 below.

Alternative 1 (No Action) provides a comparison between non-action and implementation of remedial measures in order to determine what would occur if no action was taken. Sweet Pond is currently considered unsafe and the pond is drained. In its current state this alternative can not satisfy any of the evaluation criteria. This includes Public Safety, since during flood events, even though the pond is drained, debris can clog the outlet. VANR Dam Safety does not recommend dams remain in this state on a permanent basis, and ultimately has the statutory authority to take legal action against owners of dams it has deemed unsafe. Therefore, this alternative does not satisfy any of the evaluation criteria, and was not considered as a viable alternative.

Alternative 2 (Rehabilitation of Existing Dam) provides the necessary remedial action to provide for public safety by addressing all of the noted deficiencies. It also retains the original aesthetics and recreational opportunities while maintaining the historic character of the original structure. According to correspondence from the Town of Guilford, Alternative 1 may also satisfy the Public Acceptance criterion. This alternative, from a cost perspective, is cheaper than is cheaper than Alternative 3 (New Dam Construction) but more expensive than Alternative 5 (Dam Removal). The costs for each alternative are compared in Table 3 below.

Table 3 - Summary of Alternatives Analysis

Dam Alternative	**Alt. 1 No Action**	**Alt. 2 Rehabilitation**	**Alt. 3 Replacement**	**Alt. 4 Lower Rehab.**	**Alt. 5 Removal**
Dam Safety Addressed?	No	Yes	Yes	Yes	Yes
Total Project Cost	N/A	$330,000	$631,000	$330,000	$204,000
Life (years)	N/A	50	75	50	100
Annual O&M Costs	N/A	$7,500	$5,000	$7,500	$1,000
Annualized Cost	N/A	$14,100	$13,400	$14,100	$3,040
Ease of Permitting	N/A	+	-	+ / -	+

Maintains Pond	N/A	+	+	+ / -	-
Maintain Historic Character	N/A	+	-	+ / -	- / +
Public Acceptance	N/A				

Alternative 3 (New Dam Construction) would require the existing dam to be removed and a new dam would be constructed in its place. The original location of the existing dam seems to be optimal given the channel and pond topography and therefore if a new dam were to be constructed it should be done so in the original location. This alternative, while satisfying some of the criteria, does not retain the historic character of the existing dam. Additionally, even with an efficient and modern dam design, the costs would be much more expensive as compared to the rehabilitation alternative, as shown in Table 3.

Alternative 4 (Rehabilitate Existing Dam at Lower Height) would require reducing the height of the existing dam to a level where it no longer compromises public safety. The dam height would be reduced to a level where there is still an impoundment, but the dam would no longer impound a volume of water that could potentially cause downstream flooding in the case of a breach. This alternative only satisfies the public safety criteria. In its final state the historic character would be compromised, and the historic character and aesthetics of both the dam and the pond would be significantly altered from its existing state. To ensure that this alternative was safe and provided an acceptable expected design life, rehabilitative measures would be required. These measures would be similar to those required in Alternative 2, and would also include work to remove accumulated sediments from in the area upstream of the dam. Annual maintenance costs would also be incurred to operate and maintain the dam in a safe and satisfactory condition. The overall costs associated with this alternative are estimated to be approximately the same as Alternative 2, rehabilitating the dam at its current height. No significant cost savings would be recognized over Alternative 2, and the historic character and aesthetics of the dam and pond would be significantly altered.

Alternative 5 (Dam Removal) requires the permanent removal of the dam, in its entirety. By implementing this alternative, the pond and stream channel would revert to its natural state prior to the construction of a dam. Historic reports indicate that a dam was first constructed on this location in the late 1700's. While this alternative satisfies the public safety criteria and is the lowest in overall estimated costs, the historic character and aesthetic value of the dam and the pond would be vastly altered.