Chapin Spencer
Public Works Director

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REQUEST FOR PROPOSAL – TECHNICAL ASSISTANCE
Water Storage Tank Roof Assessment

Date of Issuance: January 31, 2018

Issued by: City of Burlington Department of Public Works – Water Resources (DPW-WR)

Due Date for Proposals: Friday, February 23, 2018, 2:00 p.m.

Issuing Point of Contact:

Ashley Walenty, Water Resources Engineer
53 Lavalley Lane, Burlington, VT 05401
802.495.9976 (c)
awalenty@burlingtonvt.gov

INTRODUCTION AND GENERAL SCOPE OF WORK

Burlington DPW – Water Resources (DPW-WR) is seeking proposals for the structural analysis of the two (2) water storage tank roofs located on Main Street, across from the UVM Davis Center. The water storage tank roofs were constructed in 1981 and consist of pre-stressed double tee beams, pre-stressed roof planks, and support columns. The roof creates approximately 2 acres of impervious surfaces which is causing additional peak flows at the Main Wastewater Treatment plant during wet weather events. DPW-WR is investigating wet weather mitigation options at the water storage tanks which potentially could include the installation of a green roof. Additionally, DPW-WR is exploring the installation of solar panels. The structural analysis and assessment desired shall indicate the current loading conditions the roof is under, including its current factor of safety, any additional loads the beams and roof may be capable of carrying, and suggestions on installation of solar panels should the assessment prove that the roof is capable of such installation. It is important to note that we are looking for the most cost-effective proposal, the best solution at the most reasonable cost. The selected Consultant shall submit a memo detailing the findings from the assessment with structural calculations stamped by a Professional Engineer registered in the State of Vermont.

The technical specifications and Appendix A, located at the end of this RFP, provide available

information on the construction of the water storage tank roofs. A draft scope of work is included in the Draft Agreement included herein.

ADDITIONAL DPW SUPPLIED DATA/EFFORT

The following owner-supplied documents are provided in Appendix A at the end of this RFP.

1. Aerial map showing the reservoir and pump station.
2. Design calculations from the 1981 design of the tanks columns, beams, footings, louvers, ventilation systems and future openings.
3. Design drawings from the installation of the roof in 1981
4. University of Vermont's Senior Capstone Design project main report on green roof options.

The following documents can be obtained upon request via the Point of Contact listed herein.

1. UVM's Senior Capstone Design Project Appendices.
    a. Appendix A: Meeting Minutes
    b. Appendix B: Billable and Administrative Hours
    c. Appendix C: Available Data and Background Information
    d. Appendix D: Structural Analysis Calculations
    e. Appendix E: Design Cases and Calculations
    f. Appendix F: Aiken Roof Data
    g. Appendix G: Permits
2. Pictures of the tank roof taken inside the reservoir and of the exterior of the tank roof.

DEADLINE FOR RECEIPT OF PROPOSALS

All replies and proposals in response Request for Proposals must be received electronically and clearly marked Water Storage Tank Roof—Technical Assessment to the point of contact no later than 2:00 p.m. on the above due date. Late proposals will not be accepted.

ANSWERS TO QUESTIONS AND REVISIONS TO REQUEST FOR PROPOSALS

Due date for questions is 5:00 p.m. on Friday, February16, 2018. Any revisions, addendums and answers to questions received by the due date for questions will be sent to bidders who received this Invitation. In addition, revisions will be posted on the City's RFP web page http://burlingtonvt.gov/RFP/. It is advised that bidders sign up for the GovDelivery notification so that they will be notified of any changes to the RFP page.

SITE VISIT

Consultants can schedule a visit through the above point of contact.

PARTNERSHIPS

Consultants may team up with other firms, local or otherwise, in order to provide whatever diversity is deemed necessary for completing the project tasks.

PROPOSAL FORMAT

Contractors are encouraged to be concise. All proposals must include, but are not limited to the following:

1. Signed and notarized attachments Livable Wage Ordinance Form, Outsourcing

Ordinance Form and Union Deterrence Ordinance Form;

2. A cost proposal with estimated start/end dates, and signature and dating by authorized representative for the submitting firm;
3. A Letter of Transmittal and two copies of the proposal if sent through the mail. If sent electronically, all documents shall be in .pdf format.
4. A proposed scope of work.
5. A brief description of your firm's history and experience with related projects. If your firm intends to partner with another firm or company, also the same information about the partner(s).
6. A work history of three (3) related projects showing for each:
    a. The name, address and phone number for each client.
    b. A brief project description.
    c. A statement as to whether the project was completed on time and within budget.
7. The location of the office from which the management of the project will take place.

PROPOSAL EVALUATION

Proposals will be reviewed and evaluated by DPW staff based on the information provided. Additional information may be requested prior to final selection. It is anticipated that a decision will be made within 30 days of the due date. The selected contractor must be willing to enter into a Contractual Agreement with the City similar to the attached Draft Agreement.

CONTRACT REQUIREMENTS

Contractors are advised to review the Draft Agreement, the Specifications for Contractor Services, the Livable Wage, Outsourcing Policy, and Union Deterrence Ordinances in advance of submitting a proposal. The City reserves the right to alter or amend any or all of these provisions in the final project contract.

INDEMNIFICATION

The proposer shall be prepared to indemnify, defend and hold harmless the City and its officers and employees from liability and any claims, suits, expenses, losses, judgments, and damages arising as a result of the proposer's acts and/or omissions in the performance of the work should it be selected by DPW. Please review the Specifications for Contractor Services for details.

LIMITATIONS OF LIABILITY

The City assumes no responsibility or liability for costs incurred by parties responding to this Request for Proposals.

OWNERSHIP OF DOCUMENTS

Proposals, plans, specifications, and other documents prepared and submitted under this RFP shall become the property of the City. Proposals, plans, specifications, basis of designs, electronic data, designs and reports prepared under any agreement between the selected contractor or consultant and the City shall become the property of the City. Records shall be

furnished to the City by the Contractor upon request at any time, however the Contractor or Consultant may retain copies of the original documents.

PUBLIC RECORDS

Any and all records submitted to the City, whether electronic, paper, or otherwise recorded, are subject to the Vermont Public Records Act. The determination of how those records must be handled is solely within the purview of City. All records considered to be trade secrets, as that term is defined by subsection 317(c)(9) of the Vermont Public Records Act, shall be identified, as shall all other records considered to be exempt under the Act. It is not sufficient to merely state generally that the proposal is proprietary or a trade secret or is otherwise exempt. Particular records, pages or section which are believed to be exempt must be specifically identified as such and must be separated from other records with a convincing explanation and rationale sufficient to justify each exemption from release consistent with Section 317 of Title 1 of the Vermont Statutes Annotated.

OTHER CONDITIONS

The City reserves the right to continue with the consultant selected through future phases of the project (Final and Construction Engineering) or to seek additional proposals from other qualified firms.

The City of Burlington reserves the right to seek clarification of any proposal submitted and to select the proposal considered to best promote the public interest.

The cost of preparing, submitting and presenting a proposal is the sole expense of the consultant. The City reserves the right to reject any and all proposals received as a result of this solicitation, to re-advertise the project, to negotiate with any qualified source, to waive any formality and any technicalities or to cancel the RFP in part or in its entirety if it is in the best interest of the City. This solicitation of proposals in no way obligates the City to award a contract.

The consultant must be prepared to sign a contract containing, among other things, conditions related to indemnification, insurance requirements and compliance with various City ordinances including Livable Wage, Union Deterrence and Outsourcing.

It is expected that all consultants will make good faith efforts to solicit DBE sub-consultants.

DRAFT AGREEMENT

CITY OF BURLINGTON, VERMONT
CONTRACT AGREEMENT
FOR ENGINEERING SERVICES

THIS AGREEMENT is made this _____ day of _____, 2018, by and between the City of Burlington, VT, hereinafter referred to as the CITY and _____, a corporation, with its principal place of business in, hereinafter referred to as the CONSULTANT.

The CITY wishes to employ the CONSULTANT for Technical Assistance Services for the Water Storage Tank Roof Assessment Project in Burlington, Vermont.

WHEREAS the CONSULTANT is ready, willing, and able to perform the required services;

NOW THEREFORE, in consideration of these premises and the mutual covenants herein set forth, it is agreed by the parties hereto as follows:

1. SCOPE OF WORK

The CONSULTANT shall provide services necessary to ensure the successful completion of the project under consideration as set forth in Attachment A - Request for Proposals from the Department of Public Works dated _____, Attachment B - CONSULTANT'S Technical Proposal dated _____, Attachment C - CONSULTANT'S Cost Proposal dated _____, which are incorporated herein and made a part of this Agreement. The outcome of this work is the completion for the City Water Reservoir Tank Roof Assessment Project of an assessment and evaluation of the City's two (2) water storage reservoir tank roofs, and recommendation(s) for solar panel installation based on assessment data. The Consultant shall submit a memo detailing the findings from the assessment with structural calculations stamped by a Professional Engineer registered in the State of Vermont.

Should it become necessary for the CONSULTANT to procure sub-consultant services, this selection will be subject to approval by the CITY. It is expected that any solicitations by the CONSULTANT will include reference to the Federal Equal Employment Opportunity (Executive Order 11246), the FHWA Title VI Non-Discrimination Program, Vermont Agency of Transportation's Disadvantaged Business Enterprises Policy (CA-110) and the CITY'S Livable Wage Ordinance.

2. BEGINNING OF WORK AND TERMINATION

This Agreement shall be effective upon execution and shall be completed on or before _____.

3. THE AGREEMENT FEE

A. General. The CITY agrees to pay the CONSULTANT and the CONSULTANT agrees to accept as full compensation for performance of all services and expenses (including those of sub-consultants) encompassed under this Agreement, payment at the rates specified under the CONSULTANT's scope of services and submitted to the CITY in CONSULTANTS Cost Proposal dated _____.

B. Maximum Limiting Amount. The total amount to be paid to the CONSULTANT for all services shall not exceed a maximum limiting amount of _____, without duly authorized written approval.

4. PAYMENT PROCEDURES

One copy of each invoice and backup documentation for expenses shall be submitted to:

Ashley Walenty, Water Resources Engineer
53 Lavalley Lane, Burlington, VT 05401
802.495.9976 (c)
awalenty@burlingtonvt.gov

5. ATTACHMENTS

The following attachments are adopted by reference and made part of this Agreement:

ATTACHMENT A – Department of Public Works, Request for Proposals, ___, dated __, 2017.

ATTACHMENT B – CONSULTANT'S Proposed Scope of Work , _____, dated ____, 2017.

ATTACHMENT C – CONSULTANT'S Cost Proposal, _____, dated _____,2017.

ATTACHMENT D – City of Burlington Specifications for Contractor Services & Special Conditions

ATTACHMENT E – Insurance Certificate(s) from CONSULTANT

ATTACHMENT F – Livable Wage Ordinance Form

If a provision in this Agreement contradicts any other provision that has been incorporated by reference then the Agreement shall apply. In addition, the provisions of the Request for Proposals, Standard Contract Conditions and the Burlington City Ordinances shall prevail over any inconsistent or contradictory provisions set forth in the Contractor's Proposal.

IN WITNESS WHEREOF, the parties hereto have caused this Agreement to be executed as of the day and year first written above.

By: _____

Title: _____

Date: _____

City of Burlington, Vermont

By: _____
Chapin Spencer, Director of Public Works

Date: _____

Approved as to form and substance by the City Attorney Office:

_____ _____
Date

CONTRACTOR CONTRACT ATTACHMENT:

Specifications for Contractor Services

Includes:

1. **ABBREVIATIONS AND DEFINITIONS**
2. **INDEMNIFICATION**
3. **INSURANCE**
4. **COMPLIANCE WITH LAWS**
5. **CONTRACTUAL AGREEMENTS**
6. **OPERATIONAL STANDARDS**
7. **PROJECT DEVELOPMENT AND STANDARDS**
8. **PAYMENT FOR SERVICES RENDERED**
9. **AUDIT REQUIREMENTS**
10. **SECRETARY OF STATE**

Section 1: ABBREVIATIONS AND DEFINITIONS

Wherever used in these Specifications for Contractor Services or in any documents that these specifications pertain to or govern; abbreviations may be used in place of a word or phrase and definitions may be used to interpret statements for the meaning of words, phrases or expressions. The intent and meaning for abbreviations and definitions shall be interpreted as herein set forth:

1.01 ABBREVIATIONS.

CADD	Computer Aided Drafting and Design
CFR	Code of Federal Regulations
CPM	Critical Path Method
CSC	Contractor Selection Committee
DBE	Disadvantaged Business Enterprise
EDM	Electronic Data Media
FTP	File Transfer Protocol
LOI	Letter of Interest
RFP	Request for Proposals
SOW	Scope of Work
U.S.C.	United States Code
USDOT	United States Department of Transportation
USEPA	United States Environmental Protection Agency
VOSHA	Vermont Occupational Safety and Health Administration
V.S.A.	Vermont Statutes Annotated
VTrans (VAOT)	Vermont Agency of Transportation

1.02 DEFINITIONS. Wherever in these specifications or in other contract documents the following terms or pronouns in place of these are used, the intent and meaning shall be interpreted as follows, unless that context makes clear that another meaning is intended:

ACCEPTANCE: (Reviews-Acceptances) The Municipality's determination that a deliverable meets the requirements of the contract. The Municipality's determination shall prevail in the interpretation of acceptability.

ACCEPTANCE DATE: The date of the written notice to the contractor by the Project Manager that the project is complete and final payments, if applicable, have been approved as provided by the contract.

AGENCY: State of Vermont, Agency of Transportation, also referred to as VAOT or VTrans.
AGREEMENT: See CONTRACT.

AMENDMENT: A change to a contract that has been reviewed and approved, by signed document, by all parties to the contract.

AUDIT: An examination of the financial accounting and record systems of an entity in accordance with Generally Accepted Governmental Auditing Standards (yellow book), applicable accounting principles, and contract terms.

CALENDAR DAY: A day as shown and sequenced on the calendar, beginning and ending at midnight, as differentiated from work days or other intermittent time references.

COMPETITIVE NEGOTIATION: A means of procurement involving negotiations, based on qualifications, as described in Title IX of Federal Property and Administrative Services Act of 1949, or the formal procedure permitted by Title 19 V.S.A. Section 10a. Any competitively procured contract awarded without using a sealed bid process is considered a negotiated contract.

CONTRACT: A written contract between the Municipality and another legally distinct entity for the provision of service(s) and/or product(s). The term contract includes all such contracts whether or not characterized as a "contract", "agreement", "miscellaneous contract", "letter of agreement", "amendment" or other similar term.

CONTRACTOR: An individual or legally distinct entity providing contractual services and/or products directly to the Municipality.

DIRECTOR: A Division manager within the Agency who reports directly to Vermont's Secretary of Transportation.

DIVISION: A major component of the Agency, headed by a member of the Agency's executive staff. Each Division is subdivided into Sections and Units.

ENGINEERING AND DESIGN RELATED SERVICES: Means program management, construction management, feasibility studies, preliminary engineering, design, engineering, surveying, mapping, or architectural related services with respect to a construction project.

EXTRA WORK OR ADDITIONAL SERVICES: Services determined to be required that are not specified in a contract.

FIXED FEE: A specific amount of money to be paid in addition to the hourly or other rates for the work performed pursuant to a contract which is determined by taking into account the size, complexity, duration, and degree of risk involved in the work. Overruns in the work and/or the duration of the work shall not warrant an increase in the fixed fee.

OVERTIME PREMIUM RATE: Time and one-half or some other multiple for hours worked in excess of 40 hours in a workweek or for hours worked on weekends, holidays, and other times when work is not generally performed.

PROGRESS PAYMENTS: Partial payments made for services performed under the contract as the work progresses, at intervals and within limitations designated in the contract.

PROGRESS REPORT: A comprehensive narrative, graphic and/or tabular document/report, whether in hard copy or electronic format, indicating actual work accomplished by the contractor.
PROJECT: All activities performed and expenditures made to accomplish a specific goal. A contract may encompass part of, or more than, one project.

PROJECT MANAGER (LOCAL PROJECT MANAGER): A Municipal representative responsible for administrative management of a project and coordination of all activities related to the project, including the contract(s) to accomplish the goals of the project.

SCOPE OF WORK: A detailed description of all services and actions required of a contractor in a contract.

STATE: The State of Vermont as represented through and by the Vermont Agency of Transportation.

SUBCONTRACTOR: An individual or legally distinct entity to whom or which the contractor sublets part of the work.

VALUABLE PAPERS: Material bearing written or printed information of importance, utility or service relating to a project or contract. Electronic information is also included.

WORK: The furnishing of all labor, materials, equipment, and/or incidentals necessary or convenient to the successful completion of the contract and carrying out of the duties and obligations imposed by the contract.

Section 2: INDEMNIFICATION

2.01 INDEPENDENCE, LIABILITY.

The Consultant will act in an independent capacity and not as officers or employees of the Municipality. The Consultant shall indemnify, defend and hold harmless the Municipality and its officers and employees from liability and any claims, suits, expenses, losses, judgments, and damages arising as a result of the Consultant's acts and/or omissions in the performance of "non-professional services" under this contract. As used herein, "non-professional services" means services provided under this Agreement other than professional services relating to the design and/or engineering of all or part of the project. The Municipality shall notify the Consultant in the event of any such claim or suit covered by this Subsection and the Consultant shall immediately retain counsel and otherwise provide a complete defense against the entire claim or suit arising out of "non-professional services" provided under this Agreement. The

Consultant shall indemnify the Municipality and its officers and employees in the event that the Municipality, its officers or employees become legally obligated to pay any damages or losses arising from any act or omission of the Consultant arising from the provision of "non-professional services" (as defined herein) under this Agreement.

The Consultant shall indemnify and hold harmless the Municipality and its officers and employees from liability and any claims, suits, expenses, losses, judgments, and damages arising as a result of the Consultant's acts and/or omissions in the performance of "professional services" under this contract. The Consultant shall not be obligated to defend the Municipality and its officers and employees against claims or suits arising from the Party's provision of engineering design services or architectural design services. The Consultant shall be obligated to indemnify and hold the Municipality, its officers and employees, harmless from and against monetary damages to third parties, together with reasonable costs, expenses and attorney's fees incurred and paid by the Municipality in defending claims by third parties (collectively "Damages") but only in the event and to the extent such Damages are incurred and paid by the Municipality as the proximate cause of negligent acts, errors or omissions ("Professional Negligence") by the Consultant, its employees, agents, consultants and subcontractors, in providing the professional services required under this Agreement. As used herein, "Professional Negligence" or "negligent acts, errors or omissions" means a failure by the Consultant to exercise that degree of skill and care ordinarily possessed by a reasonably prudent design professional practicing in the same or similar locality providing such services under like or similar conditions and circumstances.

After a final judgment or settlement the Consultant may request recoupment of specific defense costs and may file suit in Vermont Superior Court, Chittenden Unit, Civil Division, requesting recoupment. The Consultant shall be entitled to recoup costs only upon a showing that such costs were entirely unrelated to the defense of any claim arising from an act or omission of the Consultant.

The Municipality is responsible for its own actions. The Consultant is not obligated to indemnify the Municipality or its officers, agents and employees for any liability of the Municipality, its officers, agents and employees attributable to its, or their own, negligent acts, errors or omissions.

In the event the Municipality, its officers, agents or employees are notified of any claims asserted against it or them to which this Indemnification clause may apply, the Municipality or its officers, agents and employees shall immediately thereafter notify the Consultant in writing that a claim to which the Indemnification Agreement may apply has been filed.

Section 3: INSURANCE

3.01 GENERAL. Prior to beginning any work pursuant to a contract, the Contractor shall have the required insurance coverages in place. The certificate(s) of insurance coverage shall be

documented on forms acceptable to the Municipality. Compliance with minimum limits and coverages, evidenced by a certificate of insurance showing policies and carriers that are acceptable to the Municipality, must be received prior to the effective date of the contract. The insurance policy(ies) shall provide that insurance coverage cannot be canceled or revised without thirty (30) days prior notice to the Municipality. If the contract is for a period greater than one year, evidence of continuing coverage must be submitted to the Municipality on an annual basis. Certified copies of any insurance policies may be required. Each policy shall name the Municipality and the State of Vermont as additional insured for liabilities arising out of the contractor's actions, errors, and/or omissions under this agreement.

The contractor shall:

(a) Verify that all subcontractors, agents or workers meet the minimum coverages and limits;

(b) Maintain current certificates of coverage for all subcontractors, agents and/or workers;

(c) Where appropriate, verify that all coverages include protection for activities involving hazardous materials; and

(d) Verify that all work activities related to the contract are covered with at least the following minimum coverages and limits.

3.02 WORKERS COMPENSATION. With respect to all operations performed, the Contractor shall carry workers' compensation insurance in accordance with the laws of the State of Vermont.

~~**3.03**~~ **GENERAL LIABILITY AND PROPERTY DAMAGE**. ***(See Special Conditions)*** ~~With respect to all operations~~
~~performed under the contract, the Contractor shall carry general liability insurance having all major divisions of coverage including, but not limited to:~~
~~Premises - Operations~~
~~Products and Completed Operations~~
~~Personal Injury Liability~~
~~Contractual Liability~~

~~The policy shall be on an occurrence form and limits shall not be less than:~~
~~$1,000,000 Per Occurrence~~
~~$1,000,000 General Aggregate~~
~~$1,000,000 Products/Completed Operations Aggregate~~
~~$ 50,000 Fire/ Legal/Liability~~

~~The Contractor shall name the Municipality and State of Vermont, and their officers and employees, as additional insured for liabilities arising out of the contractor's actions, errors, and/or omissions under this agreement.~~

3.04 AUTOMOTIVE LIABILITY. The Contractor shall carry automotive liability insurance covering all motor vehicles, including hired and non-owned coverage, used in connection with the Agreement. Limits of coverage shall not be less than: $1,000,000 combined single limit.

The Contractor shall name the Municipality and State of Vermont, and their officers and employees, as additional insured for liabilities arising out of the contractor's actions, errors, and/or omissions under this agreement.

No warranty is made that the coverages and limits required are adequate to cover and protect the interests of the contractor for the contractor's operations. These are solely minimums that must be met to protect the interests of the Municipality.

3.05 VALUABLE PAPERS AND RECORDS INSURANCE. The contractor shall carry valuable papers insurance in a form and amount sufficient to ensure the restoration or replacement of any plans, drawings, field notes, or other information or data relating to the work, whether supplied by the Municipality or developed by the contractor, subcontractor, worker or agent, in the event of loss, impairment or destruction. Such coverage shall remain in force until the final plans as well as all related materials have been delivered by the contractor to, and accepted by, the Municipality.

Unless otherwise provided, Valuable Papers and Records Insurance shall provide coverage on an "individual occurrence" basis with limits in the amount of one hundred and fifty thousand dollars ($150,000) when the insured items are in the contractor's possession, and in the amount of forty thousand dollars ($40,000) regardless of the physical location of the insured items.

~~**3.06 RAILROAD PROTECTIVE LIABILITY.** When the contract requires work on, over or under the right-of-way of any railroad, the contractor shall provide and file with the Municipality, with respect to the operations that it or its subcontractor perform under the contract, Railroad Protective Liability Insurance for and on behalf of the railroad as named insured, with the Municipality and State of Vermont named as additional insured, providing for coverage limits of:~~

(a) ~~not less than two million dollars ($2,000,000) for all damages arising out of any one accident or occurrence, in connection with bodily injury or death and/or injury to or destruction of property; and~~

(b) ~~subject to that limit per accident, a total (or aggregate) limit of six million dollars ($6,000,000) for all injuries to persons or property during the policy period.~~

~~If such insurance is required, the contractor shall provide a certificate of insurance showing the minimum coverage indicated above to the Municipality prior to the commencement of railrelated work and/or activities, and shall maintain coverage until the work and/or activities is/are accepted by the Municipality~~

3.07 PROFESSIONAL LIABILITY INSURANCE. ***(See Special Conditions)***

(a) ~~**General.** When performing "engineering and design" related services, or upon the request of the State or Municipality, the contractor shall carry architects/engineers professional liability insurance covering errors and omissions made during performance of contractual duties with the following minimum limits:~~

~~$2,000,000 – Annual Aggregate~~
~~$2,000,000 – Per Occurrence~~

(b) **Deductibles.** The contractor shall be responsible for any and all deductibles.

(c) **Coverage.** Prior to performing any work, the contractor shall provide evidence of professional liability insurance coverage defined under this Section. In addition, the contractor shall maintain continuous professional liability coverage for the period of the contract and for a period of five years following substantial completion of construction.

Section 4: COMPLIANCE WITH LAWS

4.01 APPLICABLE LAW: This Agreement will be governed by the laws of the State of Vermont.

4.02 GENERAL COMPLIANCE WITH LAWS; RESPONSIBILITY FOR VIOLATION.
The contractor shall observe and comply with all federal, state, and municipal laws, bylaws, ordinances, and regulations in any manner affecting the conduct of the work and the action or operation of those engaged in the work, including all such orders or decrees as exist at present and those which may be enacted, adopted, or issued later by bodies or tribunals having any jurisdiction or authority over the work; and the contractor shall defend, indemnify and save harmless the State, any affected railroad(s), and any affected municipality(ies), and all their officers, agents, and employees against any claim or liability arising from or based on the violation of any such law, bylaws ordinances, regulations, order, or decree, whether by the contractor in person, its employee(s), or by the contractor's subcontractor(s) or agent(s), or employee(s) or agents thereof.

If the contractor discovers any provision(s) in the contract contrary to or inconsistent with any law, ordinance, regulation, order, or decree, the contractor shall immediately report it to the

Local Project Manager in writing.

In particular, but not limited thereto, the contractor's attention is directed to the various regulations promulgated and enforced by the United States, VOSHA, environmental protection, and other resource agencies.

The Contractor shall comply with all applicable Federal, State and local laws.

4.03 SEVERABILITY. Provisions of the contract shall be interpreted and implemented in a manner consistent with each other and using procedures that will achieve the intent of both parties. If for any reason a provision in the contract is unenforceable or invalid, that provision shall be deemed severed from the contract, and the remaining provisions shall be carried out with the same force and effect as if the severed provisions had never been a part of the contract.

4.04 DEBARMENT CERTIFICATION. By signing a contract, the contractor certifies to the best of its knowledge and belief that neither it nor its principals:

(a) Is currently under suspension, debarment, voluntary exclusion or determination of ineligibility by any state/federal agency;

(b) Are not presently suspended, debarred, voluntarily excluded or determined ineligible by any federal/state agency;

(c) Do not have a proposed debarment pending; and

(d) Have not been indicted, convicted, or had a civil judgment rendered against him/her/it by a court of competent jurisdiction in any matter involving fraud or official misconduct within the past three (3) years.

Exceptions will not necessarily result in denial or termination of the contract, but will be considered in determining the contractor's responsibility. The contract shall indicate any exception, identify to whom or to what agency it applies, and state the date(s) of any and all action(s). Providing false information may result in criminal prosecution and/or administrative sanctions.

4.05 LOBBYING. The contractor certifies, by signing the contract, that to the best of its knowledge, belief, and ability:

(a) No state/federal appropriated funds have been paid or will be paid by or to any person influencing or attempting to influence an officer or employee of a government agency, a member of Congress, an officer or employee of Congress,

or an employee of a member of Congress in connection with the awarding of any state/federal contract, the making of any state/federal grant, the making of any state/federal loan, the entering into of any cooperative agreement, or the extension, renewal, amendment or modification of any state/federal contract grant, loan or cooperative agreement.

(b) If any funds, other than state/federal appropriated funds, have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any state/federal agency, a member of Congress, or an employee of a member of Congress in connection with this state/federal contract grant loan, or cooperative agreement, the contractor shall complete and submit Standard FormLLL "Disclosure Form to Report Lobbying" in accordance with its instructions.

(c) That it shall require that the language of this Certification be included in the award documents for all sub awards at all tiers (including subcontractors, subgrants and agreements under grants, loans and cooperative agreements) and that all sub recipients shall certify and disclose accordingly.

This certification is a material representation of fact, upon which reliance was placed when the contract was made or entered into. Submission of this certification is a prerequisite for making or entering into the contract, imposed by Title 31, Section 1352 U.S.C.

For any contract utilizing funds from the Federal Transit Administration (FTA) totaling more than One Hundred Thousand Dollars ($100,000) a separate lobbying certificate must be filled out, signed, and submitted by the contractor, at the time of the contract award. The Municipality will provide the certificate to contractors who are required to comply with this obligation. It is the Contractor's responsibility to complete and submit the form. Failure of the municipality to provide the form does not alleviate the Contractor's responsibility.

~~4.06 DISADVANTAGED BUSINESS ENTERPRISES (DBE) POLICY REQUIREMENTS.~~

~~Under the terms of the contract, the expression referred to as DBE shall be considered equivalent to the Minority Business Enterprises (MBE) and Women Business Enterprises (WBE) as defined under 49 CFR Part 26.~~

(a) ~~Policy: It is the policy of the USDOT that DBEs shall have the maximum opportunity to participate in the performance of contracts financed in whole or in part with federal funds. Consequently, the DBE requirements of 49 CFR Part 26 apply to this contract.~~

(b) ~~DBE Obligation: The Municipality and its contractors agree to ensure that DBEs have the maximum opportunity to participate in the performance of contracts and subcontracts financed in whole or in part with federal funds. The~~

~~Municipality and its contractors shall not discriminate on the basis of race, color, sex, or national origin in the award and performance of USDOT assisted contracts.~~

(c) ~~Sanctions for Noncompliance: The contractor is hereby advised that failure of a contractor or subcontractor performing work under this contract to carry out the requirements established under Sections 4.06 (a) and (b) shall constitute a breach of contract and, after notification by the Municipality, may result in termination of this contract by the Municipality or such remedy as the Municipality may deem appropriate.~~

(d) ~~Inclusions in Subcontracts: The contractor shall insert the following DBE policy requirements in each of its subcontracts and shall insert a clause requiring its subcontractors to include these same requirements in any lower tier subcontracts that the subcontractors may enter into, together with a clause requiring the inclusion of the DBE policy requirements in any further subcontracts that may in turn be made:~~

~~"The contractor or subcontractor shall not discriminate on the basis of race, color, sex, or national origin in the performance of this contract. The contractor shall carry out applicable requirements of 49 CFR Part 26 in the award and administration of DOTassisted contracts. Failure by the contractor to carry out these requirements is a material breach of this contract, which may result in the termination of this contract or such other remedy as the contractor deems appropriate."~~

~~This DBE policy must be included in all subcontracts, and shall not be incorporated by reference.~~

(e) ~~VAOT Annual DBE Goal: VAOT sets an overall annual goal for DBE participation on federally funded contracts, that is reviewed and revised each year, in accordance with the requirements of 49 CFR Section 26.45. For the specification of the overall annual DBE goal and an explanation of goal-setting methodology, contractors are directed to the VAOT DBE webpage at http://www.aot.state.vt.us/CivilRights/DBE.htm.~~

4.07 CIVIL RIGHTS, EQUAL EMPLOYMENT OPPORTUNITY AND AMERICANS WITH DISABILITES ACT. During performance of the contract, the contractor will not discriminate against any employee or applicant for employment because of political or religious affiliation, race, color, national origin, place of birth, ancestry, age, sex, sexual orientation, gender identity, marital status, veteran status, disability, HIV positive status or genetic information.

The contractor shall comply with the applicable provisions of Title VI of the Civil Rights Act of 1964 as amended, and Executive Order 11246 as amended by Executive Order 11375 and as supplemented in Department of Labor regulations (41 CFR chapter 60). The contractor shall also comply with the rules, regulations and relevant orders of the Secretary of Labor, Nondiscrimination regulations 49 CFR Part 21 through Appendix C. Accordingly, all subcontracts shall include reference to the above.

The contractor shall comply with all the requirements of Title 21, V.S.A., Chapter 5, Subchapter 6, relating to fair employment practices to the full extent applicable. Contractor shall also ensure, to the full extent required by the Americans with Disabilities Act of 1990, as amended, that qualified individuals with disabilities receive equitable access to the services, programs, and activities provided by the Contractor under this Agreement. Contractor further agrees to include this provision in all subcontracts

4.08 ENVIRONMENTAL REGULATIONS. Any contract in excess of one hundred thousand dollars ($100,000.00) shall comply with all applicable standards, orders, or requirements issued under Section 306 of the Clean Air Act (42 U.S.C. Part 1857(h)), Section 508 of the Clean Water Act (33 U.S.C. Part 1368), Executive Order 11738, and Environmental Protection Agency regulation (40 CFR Part 15), that prohibit the use, under non-exempt federal contracts, grants or loans, of facilities included on the EPA list of Violating Facilities. The provisions require reporting of violations to the state, Agency and to the USEPA Assistant Administrator for Enforcement (EN-329).

In the event of conflict between these environmental requirements and pollution control laws, rules, or regulations of other federal, state, or local agencies, the more restrictive laws, rules, or regulations shall apply.

4.09 FALSE STATEMENTS. To assure high quality and durable construction in conformity with approved plans and specifications and a high degree of reliability on statements and representations made by engineers, contractors, suppliers, and workers on Federal-aid highway projects, it is essential that all persons concerned with the project perform their functions as carefully, thoroughly, and honestly as possible. Willful falsification, distortion, or misrepresentation with respect to any facts related to the project is a violation of Federal law (see, e.g., 18 U.S.C. 1020) as well as the laws of the State of Vermont.

4.10 PROMPT PAYMENT.

(a) The contractor, by accepting and signing the contract, agrees to fully comply with the provisions of 9 V.S.A. Chapter 102, also referred to as Act No. 74 of 1991 or the Prompt Payment Act, as amended. This will apply whether or not the contract falls under the literal provisions of 9 V.S.A. Chapter 102.

In accordance with 9 V.S.A. Section 4003, notwithstanding any contrary contract, payments shall be made within seven days from receipt of a corresponding progress payment by the Municipality to the contractor, or seven days after receipt of a subcontractor's invoice, whichever is later. Failure to comply constitutes a violation of this contract.

Violations shall be reported to the VTrans Office of Civil Rights for review. Failure to resolve disputes in a timely manner will result in a complaint made to the Agency's Chief of Contract Administration. In the Agency's judgment, appropriate penalties may be invoked for failure to comply with this specification. Penalties may include debarment or suspension of the ability to submit proposals.

(b) The requirements of Section 4.10a must be included in all subcontracts.

4.11 CHILD SUPPORT PAYMENTS: By signing the Contract the Contractor certifies, as of the date of signing the Agreement, that they are (a) not under an obligation to pay child support; or (b) is under such an obligation and is in good standing with respect to that obligation; or (c) has agreed to a payment plan with the Vermont Office of Child Support Services and is in full compliance with that plan. If the Contractor is a sole proprietorship, the Contractor's statement applies only to the proprietor. If the Contractor is a partnership, the Contractor's statement applies to all general partners with a permanent residence in Vermont. If the Contractor is a corporation, this provision does not apply.

4.12 TAX REQUIREMENTS: By signing the Agreement, the Contractor certifies, as required by law under 32 VSA, Section 3113, that under the pains and penalties of perjury, he/she is in good standing with respect to payment, or in full compliance with a plan to pay, any and all taxes due the State of Vermont as of the date of signature on the Agreement.

4.13 ENERGY CONSERVATION: The Contractor shall recognize mandatory standards and policies relating to energy efficiency that are contained in the State energy conservation plan issued in compliance with the Energy Policy and Conservation Act (P.L. 94-163, 89 Stat. 871).

Section 5: CONTRACTUAL AGREEMENTS

5.01 ENTIRE AGREEMENT: This Agreement represents the entire agreement between the parties on the subject matter. All prior agreements, representations, statements, negotiations, and understandings shall have no effect

5.02 ADMINISTRATION REQUIREMENTS. By signing the contract the contractor agrees to comply with the following provisions and certifies that the contractor is in compliance with the provisions of 49 CFR Part 18.36 – Procurement,(i)- Contract Provisions, with principal reference to the following:

(a) MUNICIPALITY'S OPTION TO TERMINATE. The contract may be terminated in accordance with the following provisions:

(1) Breach of Contract: Administrative remedies - the Municipality may terminate the contract for breach of contract. Termination for breach of contract will be without further compensation to the contractor.

(2) Termination for Cause: Upon written notice to the contractor, the Municipality may terminate the contract, as of the date specified in the written notice by the Municipality, if the contractor fails to complete the designated work to the satisfaction of the Municipality within the time schedule agreed upon. The contractor shall be compensated on the basis of the work performed and accepted by the Municipality at the date of termination.

(3) Termination for Convenience: The Municipality may, at any time prior to completion of services specified under the contract, terminate the contract by submitting written notice to a contractor fifteen (15) days prior to the effective date, via certified or registered mail, of its intention to do so.

When a contract is terminated for the Municipality's convenience, payment to the contractor will be made promptly for the amount of any fees earned to the date of the notice of termination, less any payments previously made.

When the Municipality terminates the contract for its convenience, the Municipality shall make an equitable adjustment of the contract price, but in doing so shall include no payment or other consideration for anticipated profit on unperformed services.

However, if a notice of termination for convenience is given to a contractor prior to completion of twenty (20) percent of the services provided for in the contract (as set forth in the approved Work Schedule and Progress Report) the contractor will be reimbursed for that portion of any reasonable and necessary expenses incurred to the date of the notice of termination that are in excess of the amount earned under the approved fees to the date of said termination. Such requests for reimbursement shall be supported with factual data and shall be subject to the Municipality's approval.

The contractor shall make no claim for additional compensation against

the Municipality by reason of such termination.

(4) Lack of Funding: If postponement, suspension, abandonment, or termination is ordered by the Municipality because it lacks sufficient funding to complete or proceed with the project, the contractor may not make a claim against the Municipality in any form or forum for loss of anticipated profit.

(b) Proprietary Rights: If a patentable discovery or invention results from work performed under the contract, all rights accruing from such discovery or invention shall be the sole property of the contractor. The State, the Municipality, and the United States Government shall have an irrevocable, nonexclusive, non-transferable, and royalty free license to practice each invention in the manufacture, use, and disposition, according to law, of any article or material or use of method that may be developed, as a part of the work under the contract.

(c) Publications: All data, EDM, valuable papers, photographs and any other documents produced under the terms of the contract shall become the property of the Municipality. The contractor agrees to allow access to all data, EDM, valuable papers, photographs, and other documents to the Municipality, the State or United States Government at all times. The contractor shall not copyright any material originating under the contract without prior written approval of the Municipality.

(d) Ownership of the Work: All studies, data sheets, survey notes, subsoil information, drawings, tracings, estimates, specifications, proposals, diagrams, calculations, EDM, photographs, and other material prepared or collected by the contractor, hereafter referred to as "instruments of professional service," shall become the property of the Municipality as they are prepared and/or developed during performance of the work of the contract. If a contractor uses a proprietary system or method to perform the work, only the product will become the property of the Municipality.

The contractor shall surrender to the Municipality upon demand or submit for inspection at any time, any instruments of professional service that have been collected, undertaken or completed by the contractor pursuant to the contract. Upon completion of the work, these instruments of professional service will be appropriately endorsed by the contractor and turned over to the Municipality.

Data and publication rights to any instruments of professional services produced under the contract are reserved to the Municipality and shall not be copyrighted

by the contractor at any time without written approval of the Municipality. No publication or publicity of the work, in part or in total, shall be made without the consent of the Municipality, except that contractors may in general terms use previously developed instruments of professional service to describe its abilities for a project in promotional materials.

(e) Rights and Remedies Additional: The rights and remedies of the Municipality under this article are in addition to any other rights and remedies that the Municipality may possess by law or under this contract.

(f) Decisions Final and Binding: Decisions of the Municipality on matters discussed in this article shall be final and binding.

5.03 PERSONNEL REQUIREMENTS AND CONDITIONS. The contractor shall employ only qualified personnel to supervise and perform the work. The Municipality shall have the right to approve or disapprove key personnel assigned to administer activities related to the contract.

The contractor shall supply resumes for staff proposed to work on assignment(s) under contracts for review, and acceptance, or rejection, by the Municipality. This requirement may be waived if the proposed staff has worked on similar projects for the Municipality in the past. The Municipality retains the right to interview the proposed staff.

Except with the approval of the Municipality, during the life of the contract, the contractor shall not employ:

(a) Personnel on the payroll of the State or the Municipality who are directly involved with the awarding, administration, monitoring, or performance of the contract or any project that is the subject of the contract.

(b) Any person so involved within one (1) year of termination of employment with the State or the Municipality.

The contractor warrants that no company or person has been employed or retained, other than a bonafide employee working solely for the contractor, to solicit or secure the contract, and that no company or person has been paid or has a contract with the contractor to be paid, other than a bonafide employee working solely for the contractor, any fee, commission, percentage, brokerage fee, gift, or any other consideration, contingent upon or resulting from the award or making of the contract. For breach or violation of this warranty, the Municipality shall have the right to terminate the contract, without liability to the Municipality, and to retrieve all costs incurred by the Municipality in the performance of the contract.

The Municipality reserves the right to require removal of any person employed by a contractor from work related to the contract for misconduct, incompetence, or negligence, or who

neglects or refuses to comply with the requirements of the contract. The decision of the Municipality, in the due and proper performance of its duties, shall be final and not subject to challenge or appeal beyond those described in Section 5.12.

5.04 NO EMPLOYEE BENEFITS FOR CONTRACTOR: The Contractor understands that the Municipality will not provide any individual retirement benefits, group life insurance, group health and dental insurance, vacation or sick leave, workers compensation or other benefits or services available to Municipal employees, nor will the Municipality withhold any state or federal taxes except as required under applicable tax laws, which shall be determined in advance of signing of the Agreement. The Contractor understands that all tax returns required by the Internal Revenue Code and the State of Vermont, including but not limited to income, withholding, sales and use, and rooms and meals, must be filed by the Contractor, and information as to Agreement income will be provided by the State of Vermont to the Internal Revenue Service and the Vermont Department of Taxes.

5.05 ASSIGNMENTS, TRANSFERS AND SUBLETTING. The contractor shall not assign, sublet, or transfer any interest in the work covered by the contract without prior written consent of the Municipality and appropriate federal agencies, if applicable. Further, if any subcontractor participates in any work involving additional services, the estimated extent and cost of the contemplated work must receive prior written consent of the Municipality. The approval or consent to assign, sublet or assign any portion of the work shall in no way relieve the contractor of responsibility for the performance of that portion of the work so affected. Except as otherwise provided in these specifications, the form of the subcontractor's contract shall be as developed by the contractor.

Any authorized subcontracts shall contain all of the same provisions specified for and attached to the original contract with the Municipality. The Municipality shall be provided copies of all signed subcontracts.

5.06 PERFORMANCE AND COMPLETION OF WORK. The contractor shall perform the services specified in accordance with the terms of the contract and shall complete the contracted services by the completion dates specified in the contract.

With the exception of ongoing obligations (*e.g.*, insurance, ownership of the work, and appearances) upon completion of all services covered under the contract and payment of the agreed upon fee, the contract with its mutual obligations shall be terminated.

If, at any time during or after performance of the contract, the contractor discovers any design errors, change(s) in standards, work product, or other issues that warrant change(s), the contractor shall notify the Local Project Manager immediately. This paragraph also applies to those projects that are under construction or have been constructed.

5.07 CONTINUING OBLIGATIONS. The contractor agrees that if, because of death(s) or other occurrences, it becomes impossible to effectively perform its services in compliance with the contract, neither the contractor nor its surviving principals shall be relieved of their obligations to complete the services under the contract. However, the Municipality may terminate the contract if it considers a death, incapacity, or other removal of any principal(s) and/or key project personnel to be a loss of such magnitude that it would affect the contractor's ability to satisfactorily comply with the contract.

5.08 APPEARANCES.

(a) Hearings and Conferences: The contractor shall provide professional services required by the Municipality that are necessary for furtherance of any work covered under the contract. Professional services shall include appropriate representation at design conferences, public gatherings and hearings, and appearances before any legislative body, commission, board, or court, to justify, explain and defend its services provided under the contract.

The contractor shall perform any liaison that the Municipality deems necessary for the furtherance of the work and participate with the Municipality, at any reasonable time, in conferences, concerning interpretation and evaluation of all services provided under the contract.

The contractor further agrees to participate in meetings with the Municipality, the State and applicable Federal Agencies, and any other interested or affected participants for the purpose of review or resolution of any conflicts pertaining to the contract. The contractor shall be equitably paid for such services, and for any reasonable expenses incurred in relation thereto, in accordance with the contract.

(b) Appearance as Witness: If and when required by the Municipality, the contractor, or an appropriate representative, shall prepare for and appear in, on behalf of the Municipality, any litigation or other legal proceeding concerning any relevant project or related contract. The contractor shall be equitably paid for such services, and for any reasonable expenses incurred in relation thereto, in accordance with the contract.

5.09 CHANGES AND AMENDMENTS. Extra work, additional services or changes may necessitate the need to amend the contract. Extra work, additional services or changes must be properly documented and approved by the Local Project Manager, or an authorized official delegated this responsibility, prior to initiating action of any extra work, additional services, or changes.

5.10 APPENDICES. The Municipality may attach to these specifications appendices containing various forms and typical sample sheets for guidance and assistance to the contractor in the performance of the work. It is understood that such forms and samples may be modified, altered, and augmented from time to time by the Municipality. It is the responsibility of the contractor to ensure that it has the latest versions applicable to the contract.

5.11 EXTENSION OF TIME. The contractor agrees to perform the work in a diligent and timely manner; no charges or claims for damages shall be made by the contractor for delays or hindrances from any cause whatsoever. Such delays or hindrances, if any, may be compensated for by an extension of time for such reasonable period as the Municipality may decide. Time extensions may be granted only by amendment, and only for excusable delays such as delays beyond the control of the contractor and without the fault or negligence of the contractor.

The contractor may, with justification, request in writing an extension of the allotted time for completion of the work. A request for extension will be evaluated, and if the Municipality determines that the justification is valid, an extension of time for completion of the work may be granted. A request for extension of time must be made before the contractor is in default.

The decision of the Municipality relative to granting an extension of time shall be final and binding.

5.12 RESOLUTION OF CONTRACT DISPUTES. The parties shall attempt to resolve any disputes that may arise under the contract by negotiation. Any dispute not resolved by negotiation shall be referred to the Local Project Manager for determination. If the contractor is aggrieved by the decision of the Local Project Manager, the contractor must file an appeal following the process described below.

(a) This Section sets forth the exclusive appeal remedies available with respect to this contract. The Contractor, by signing the contract, expressly recognizes the limitation on its rights to appeal contained herein, expressly waives all other rights and remedies and agrees that the decision on any appeal, as provided herein, shall be final and conclusive. These provisions are included in this contract expressly in consideration for such waiver and agreement by the Contractor.

(b) A Contractor may appeal any determination regarding the contract by filing a notice of appeal by hand delivery or courier to the Director of Public Works. The notice of appeal shall specifically state the grounds of the protest.

(c) Within seven (7) calendar days of the notice of appeal the Contractor must file with the Municipality a detailed statement of the grounds, legal authorities and facts, including all documents and evidentiary statements, in support of the appeal. Evidentiary statements, if any, shall be submitted under penalty of

perjury. The Contractor shall have the burden of proving its appeal by clear and convincing evidence.

(d) Failure to file a notice of appeal or a detailed statement within the applicable period shall constitute an unconditional waiver of the right to appeal the evaluation or qualified process and decisions thereunder.

(e) Unless otherwise required by law, no evidentiary hearing or oral argument shall be provided, except the Director of Public Works, in its sole discretion, may decide to permit a hearing or argument if it determines that such hearing or argument is necessary for the protection of the public interest. The Director of Public Works shall issue a written decision regarding the appeal after it receives the detailed statement of appeal. Such decision shall be final and conclusive.

(f) If the Director of Public Works concludes that the Contractor's has established a basis for appeal, the Director of Public Works will determine what remedial steps, if any, are necessary or appropriate to address the issues raised in the appeal. Such steps may include, without limitation, withdrawing or revising the decisions, or taking other appropriate actions.

5.13 EXCUSABLE FAILURE TO COMPLY WITH TIME SCHEDULE. Neither party hereto shall be held responsible for delay in performing the work encompassed herein when such delay is due to unforeseeable causes such as, but not limited to, acts of God or a public enemy, fire, strikes, floods, or legal acts of public authorities. In the event that any such causes for delay are of such magnitude as to prevent the complete performance of the contract within two (2) years of the originally scheduled completion date, either party may by written notice request an extension of time or terminate the contract.

5.14 NO ADVANTAGE FROM ERRORS OR OMISSIONS IN CONTRACT DOCUMENTS. Neither the contractor nor the Municipality shall take advantage or be afforded any benefit as the result of apparent error(s) or omission(s) in the contract documents. If either party discovers error(s) or omission(s), it shall immediately notify the other.

5.15 NO GIFTS OR GRATUITIES: Contractor shall not give title or possession of anything of substantial value (including property, currency, travel and/or education programs) to any officer or employee of the Municipality or the State during the term of this Agreement.

5.16 ADDITIONAL ADMINISTRATIVE REQUIREMENTS:

(a) Copeland "Anti-Kickback" Act. For any Federal-Aid Contracts or subcontracts for construction or repair, the Contractor agrees to comply with the Copeland "Anti-

Kickback" Act (18 U.S.C. Part 874) as supplemented by Department of Labor Regulations (29 CFR Part 3).

(b) Davis-Bacon Act. For any Federal-Aid construction contracts in excess of $2,000, the Contractor agrees to comply with the Davis-Bacon Act (40 U.S.C. Section 276a to 267a-7) as supplemented by Department of Labor Regulations (29 CFR Part 5).

(c) Work Hours. For any Federal-Aid construction contracts in excess of $ 2,000, or in excess of $ 2,500 for other contracts involving employment of mechanics or laborers, the Contractor agrees to comply with the Sections 103 and 107 of the Contract Working Hours and Safety Standards Act (40 U.S.C. Section 327-330) as supplemented by Department of Labor Regulations (29 CFR Part 5).

(d) Exclusionary or Discriminatory Specifications. Section 3(a)(2)(C) of the UMT Act of 1964, as amended, prohibits the use of grant of loan funds to support procurements utilizing exclusionary of discriminatory specifications.

Section 6: OPERATIONAL STANDARDS

6.01 RESPONSIBILITY FOR SUPERVISION. The contractor shall be responsible for supervision of contractor employees and subcontractors for all work performed under the contract and shall be solely responsible for all procedures, methods of analysis, interpretation, conclusions and contents of work performed under the contract.

6.02 WORK SCHEDULE AND PROGRESS REPORTS. Prior to initiating any work, the contractor shall work with the Municipality's Local Project Manager to develop a work schedule showing how the contractor will complete the various phases of work to meet the completion date and any interim submission date(s) in the contract. The Municipality will use this work schedule to monitor the contractor.

The contractor during the life of the contract shall make monthly progress reports, or as determined by the Local Project Manager, indicating the work achieved through the date of the report. The contractor shall link the monthly progress reports to the schedule. The report shall indicate any matters that have, or are anticipated to, adversely affected progress of the work. The Municipality may require the contractor to prepare a revised work schedule in the event that a specific progress achievement falls behind the scheduled progress by more than thirty (30) days. The revised work schedule shall be due as of the date specified by the Municipality.

6.03 UTILITIES. Whenever a facility or component of a private, public, or cooperatively owned utility will be affected by proposed construction, the Contractor shall consult with the Utility Section and initiate contacts and/or discussions with the affected owner(s) regarding requirements necessary for revision of facilities, both above and below ground. All revisions

must be completely and accurately exhibited on detail sheets or plans. The contractor shall inform the Municipality, in writing, of all contacts with utility facility owners, and the results thereof.

6.04 PUBLIC RELATIONS. Whenever it is necessary to perform work in the field (*e.g.*, with respect to reconnaissance, testing, construction inspection and surveying) the contractor shall endeavor to maintain good relations with the public and any affected property owners. Personnel employed by or representing the contractor shall conduct themselves with propriety. If there is need to enter upon private property to accomplish the work under the contract, the contractor shall inform property owners and/or tenants in a timely manner and in accordance with relevant statutes. All work will be done with minimum damage to the land and disturbance to the owner thereof. Upon request of the contractor, the Municipality shall furnish a letter of introduction to property owners soliciting their cooperation and explaining that the contractor is acting on behalf of the Municipality.

6.05 INSPECTION OF WORK. The Municipality, the State and applicable federal agencies shall, at all times, have access to the contractor's work for the purposes of inspection, accounting and auditing, and the contractor shall provide appropriate and necessary access to accomplish inspections, accounting, and auditing. The contractor shall permit the Municipality, the State, or representative(s) of the State and applicable federal agencies the opportunity at any time to inspect any plans, drawings, estimates, specifications, or other materials prepared or undertaken by the contractor pursuant to the contract.

A conference, visit to a site, or inspection of the work may be held at the request of the contractor, the Municipality, the State, and appropriate federal agency(ies).

6.06 WRITTEN DELIVERABLES/REPORTS. Unless otherwise identified in the scope of work, written deliverables presented under terms of the contract shall be on 8.5” by 11" paper, consecutively printed on both sides. Reports shall be bound and have a title page that identifies the name and number of the project, if applicable, and publication date. The report shall have a table of contents and each page shall be numbered consecutively. Draft reports shall be clearly identified as such.

6.07 PLANS, RECORDS AND AVAILABLE DATA. At the request of the contractor, the Municipality will make available to the contractor, at no charge, all information and data related to the contract.

<u>Any and all records submitted to the City, whether electronic, paper, or otherwise recorded, are subject to the Vermont Public Records Act. The determination of how those records must be handled is solely within the purview of City. All records considered to be trade secrets, as that term is defined by subsection 317(c)(9) of the Vermont Public Records Act, shall be identified, as shall all other records considered to be exempt under the Act. It is not sufficient to merely state generally that the proposal</u>

is proprietary or a trade secret or is otherwise exempt. Particular records, pages or section which are believed to be exempt must be specifically identified as such and must be separated from other records with a convincing explanation and rationale sufficient to justify each exemption from release consistent with Section 317 of Title 1 of the Vermont Statutes Annotated.

Section 7: PROJECT DEVELOPMENT AND STANDARDS

7.01 PLANS, RECORDS AND AVAILABLE DATA. At the request of the contractor, the Municipality will make available to the contractor, at no charge, all information and data related to the contract.

7.02 DESIGN SPECIFICATIONS, STANDARDS, MANUALS, GUIDELINES, DIRECTIVES AND POLICIES. The contractor shall comply with all applicable statutes, regulations, ordinances, specifications, manuals, standards, guidelines, policies, directives and any other requirements related to the contract.

In case of any conflict with the items referenced above, the contractor is responsible to ascertain and follow the direction provided by the Municipality.

7.03 ELECTRONIC DATA MEDIA. Contractors, subcontractors, and representative(s) thereof performing work related to the contract shall ensure that all data and information created or stored on EDM is secure and can be duplicated if the EDM mechanism is subjected to power outage or damage. For those projects that are to be stored on the VTrans plan archival system the following shall apply:

(a) CADD Requirements.

CADD requirements are available in "The Vermont Agency of Transportation CADD Standards and Procedure Manual" on the VTrans web page at http://www.vtrans.vermont.gov . VTrans has developed this manual to ensure that all electronic CADD files delivered to and taken from the Agency are in formats that can be utilized for engineering purposes without modification. VTrans will not accept or pay for any CADD files which do not adhere to the requirements specified in the CADD manual.

(b) VTrans Web Page and File Transfer Protocol (FTP) Sites - Disclaimer.

The files located on the VTrans web page and FTP sites are subject to change. The contractor is responsible for maintaining contact with VTrans to determine if any changes affect the work being produced by the contractor. Although VTrans makes every effort to ensure the accuracy of its work, it cannot guarantee that transferred files are error free. VTrans is not responsible in any way for costs or

other consequences, whether direct or indirect, that may occur to the contractor or any subsequent users of the information due to errors that may or may not be detected.

(c) Geographic Information System Requirements.

The contractor shall provide to the Municipality all spatially-referenced digital data developed for or used in a project. Such data shall conform to relevant standards and guidelines of the Vermont Geographic Information System with respect to digital media, data format, documentation, and in all other respects. Copies of the standards and guidelines can be obtained from the Vermont Center for Geographic Information, Inc., 58 South Main Street, Suite 2, Waterbury, VT 05676; (802) 882-3000 or at www.VCGI.vermont.gov .

(d) Data Specifications.

(1) Data structures (databases, data files, and other electronic information) shall provide 4-digit date century recognition. Example: 2016 provides "date century recognition," while '16 does not.

(2) All stored data shall contain date century recognition, including, but not limited to, data stored in databases and hardware/device internal system dates.

(3) Calculations and program logic shall accommodate both same century and multi-century formulas and data values. Calculations and program logic includes, but are not limited to, sort algorithms, calendar generations, event recognition, and all processing actions that use or produce data values.

(4) Interfaces to and from other systems or organizations shall prevent noncompliant dates and data from entering or exiting any State system.

(5) User interfaces (*i.e.*, screens, reports, and similar items) shall accurately show 4-digit years.

(e) General Specifications.

To provide uniform and consistent integration with electronic data transfer, all data, other than specific applications previously mentioned, shall be in Microsoft's Office format. The desktop suite includes word processing, spread

sheets and presentations. All transmissions of e-mail must be in Rich Text (RTF) or Hyper Text Markup Language (HTML) format.

7.04 REVIEWS AND APPROVALS. All work prepared by the contractor, subcontractor(s), and representatives thereof pursuant to the contract shall be subject to review and approval by the Municipality. Approval for any work shall be documented in writing.

Approvals shall not relieve a contractor of its professional obligation to correct any defects or errors in the work at the contractor's expense.

The pertinent federal entity may independently review and comment on the contract deliverables. The contractor, through the Municipality, shall respond to all official comments regardless of their source. The contractor shall supply the Municipality with written copies of all correspondence relating to reviews. All comments must be satisfactorily resolved before the affected work is advanced.

Section 8: PAYMENT FOR SERVICES RENDERED

8.01 PAYMENT PROCEDURES. The Municipality will pay the contractor, or the contractor's legal representative, progress payments monthly or as otherwise specified in the contract.

(a) General: Payment generally will be determined by the percentage of work completed as documented by a progress report of such work. The total percentage of work billed shall be within ten (10) percent of the total percentage of work completed. The percentage of work completed is based on the actual contract work produced, as outlined in the monthly progress report.

(b) Hourly-Type Contracts: For hourly type contracts, payments will be made based on documented hours worked and direct expenses encumbered, as allowed by the contract.

(c) Actual Costs and Fixed Fees: When applicable for the type of payment specified in the contract, the progress report shall summarize actual costs and any earned portion of a fixed fee.

(d) Maximum Limiting Amount Cannot Be Exceeded: The total amount invoiced for the contract and the total amount paid pursuant to the contract cannot exceed the contract's Maximum Limiting Amount.

(e) Invoices: Invoices shall be submitted to the Municipality's Local Project Manager. The invoice must adhere to all terms of the contract. The "final invoice" shall be so labeled. All invoices must:

1) Be originals signed by a company official and be accompanied by two copies, with documentation for the original and all copies.

2) Indicate the appropriate project name, project number if applicable, and contract number. When applicable, invoices shall further be broken down in detail between projects.

3) Be dated and list the period of performance for which payment is requested.

4) Include a breakdown of direct labor hours by classification of labor, phases and tasks, if applicable. For reporting purposes, however, the amounts can be combined for phases that are paid from the same funding source.

5) Not include overtime rates unless the Municipality's Local Project Manager provides prior written approval, if applicable. Information regarding overtime can be found in 48 CFR Ch. 1, Section 22.103.

6) Be accompanied by documentation to substantiate necessary charges. Documentation of all charges must accompany the original invoice and each copy.

(f) Meals and Travel Expenses: When applicable for the type of payment specified in the contract, reimbursement of expenses for meals and travel shall be limited to the current, approved in-state rates as determined by the State's non-management bargaining unit labor contract, and need not be receipted. Current in-state expense reimbursement rates may be obtained from the Vermont Department of Human Resources.

(g) Other Expenses: Expenses for the following items will be reimbursed at reasonable rates as determined by the Municipality. In all instances, receipts or bills indicating costs pertaining to the project identified, inclusive of any discounts given to the contractor, must be submitted.

1. Lodging.
2. Telephone and fax.
3. Printing and reproduction.

For printing and reproduction work performed within the contractor's firm, log sheets are sufficient if they clearly indicate the contract or project copies.

4. Postage and shipping.

Contractor shall choose the most economical type of service (regular mail, overnight express, other) workable for the situation. The use of express mail or overnight delivery should be limited to those instances when such expenditures are warranted.

Reimbursement of all other expenses is subject to approval by the Municipality and all other reimbursement requests must include receipts or other documentation to substantiate the expenses. Except as otherwise provided in the contract, all requests for reimbursement of direct expenses must reflect actual costs inclusive of any discounts given to the contractor.

The contractor must attach any sub-contractor invoices, ensure that they adhere to the terms of the contract, and include all necessary receipts and other documentation. **Mark-up on subcontractor invoices is not allowed.**

(h) Payment Is Not Acceptance: Approval given or payment made under the contract shall not be conclusive evidence of the performance of said contract, either wholly or in part. Payment shall not be construed to be acceptance of defective work or improper materials.

(i) Payment for Adjusted Work: As adjustments are required for additions, deletions, or changes to the contract, payment for such work shall be in accordance with Subsection 8.02 - Payment for Additions, Deletions or Changes and/or any applicable fees set forth in amendment(s) to the contract.

(j) If the contractor discovers error in a submitted invoice or payment, the contractor shall notify the Local Project Manager of the error prior to the submission of any additional invoices. The local project manager will provide direction on how the error is to be resolved.

8.02 PAYMENT FOR ADDITIONS, DELETIONS OR CHANGES: The Municipality may, upon written notice, require changes, additions or deletions to the work/contract. Whenever possible, any such adjustments shall be administered under the appropriate fee established in the contract based on the adjusted quantity of work.

The Municipality may, upon written notice, and without invalidating the contract, require changes resulting from revision or abandonment of work already satisfactorily performed by the contractor or changes in the scope of work.

If the value of such changes, additions or deletions is not otherwise reflected in payments to the contractor pursuant to the contract, or if such changes require additional time and/or expense to perform the work, the contract may be amended accordingly.

The contractor agrees to maintain complete and accurate records, in a form satisfactory to the Municipality, for any extra work or additional services in accordance with Subsection 6.05 - Inspection of Work. When extra work or additional services are ordered, the contractor shall perform such work or services only after an amendment has been fully executed or a written notice to proceed is issued by the Municipality.

8.03 RELIANCE BY THE MUNICIPALITY ON REPRESENTATIONS: All payments by the Municipality under this Agreement will be made in reliance upon the accuracy of all prior representations by the Contractor, including but not limited to bills, invoices, progress reports and other proofs of work.

Section 9: AUDIT REQUIREMENTS

9.01 – AUDIT REQUIREMENTS. All Contractors and subcontractors shall have on file with the VTrans Audit Section a current AF 38 Form and related documentation appropriate for the type and size of contract with the Municipality under this agreement. (See below for a link to the AF 38 Form on the VTrans website).

9.02 – INDIRECT COST CERTIFICATION. All contractors entering into a contract to provide engineering and/or design related services, regardless of amount, must have a current INDIRECT COST CERTIFICATION form on file with the VTrans Audit Section The form is available on the VTrans Contract Administration website, http://vtranscontracts.vermont.gov .

9.03 RECORD AVAILABLE FOR AUDIT. The Contractor will maintain all books, documents, payroll papers, accounting records and other evidence pertaining to costs incurred under this agreement and make them available at reasonable times during the period of the Agreement and for three years thereafter for inspection by any authorized representatives of the Municipality, the State or Federal Government. If any litigation, claim, or audit is started before the expiration of the three year period, the records shall be retained until all litigation, claims or audit findings involving the records have been resolved. The Municipality, the State, by any authorized representative, shall have the right at all reasonable times to inspect or otherwise evaluate the work performed or being performed under this Agreement.

Section 10. SECRETARY OF STATE

10.01 REGISTRATION WITH SECRETARY OF STATE. The contractor shall be registered with the Vermont Secretary of State to do business in the State of Vermont if the contractor:

(a) Is a domestic or foreign corporation.

(b) Is a resident co-partner or resident member of a co-partnership or association.

(c) Is (are) a non-resident individual(s) doing business in Vermont in his/her (their) individual capacity(ies).

(d) Is doing business in Vermont under any name other than the Contractor's own personal name.

This registration must be complete prior to contract preparation. Current registration must be maintained during the entire contract term.

SPECIAL CONDITIONS

The SPECIFICATIONS FOR CONTRACTOR SERVICES, as modified herein, shall apply to this Contract.

1.02 DEFINITIONS:

CONTRACTOR: Shall refer to Consultants when the Contract is between a Municipality and a professional consultant, or other professional services as provided.

MUNICIPALITY: As referenced shall be the City of Burlington, or City.

3.02 WORKERS' COMPENSATION. Add:

Minimum limits for Employer's Liability:

(a) Bodily Injury by Accident: $500,000 each accident
(b) Bodily Injury by Disease: $500,000 policy limit, $100,000 each employee

3.03 GENERAL LIABILITY AND PROPERTY DAMAGE. Replace this section in its entirety with the following:

With respect to all operations performed by the Consultant, subconsultants, agents or workers, it is the Consultant's responsibility to insure that general liability insurance coverage provides all major divisions of coverage including, but not limited to:

1. Premises Operations
2. Independent Contractors' Protective
3. Products and Completed Operations
4. Personal Injury Liability
5. Contractual Liability
6. Broad Form Property Damage
7. Medical Expenses
8. Collapse, Underground and Explosion Hazards

The policy shall be on an occurrence form with limits not less than:

$1,000,000	Per Occurrence
$2,000,000	General Aggregate
$2,000,000	Products/Completed Operations Aggregate
$1,000,000	Personal & Advertising Injury
$ 250,000	Fire Damage
$ 50,000	Legal/Liability
$ 5,000	Medical

The Contractor shall name the Municipality and State of Vermont, and their officers and employees, as additional insured for liabilities arising out of the contractor's actions, errors, and/or omissions under this agreement.

3.07 PROFESSIONAL LIABILITY INSURANCE. Section (a) shall be replaced in its entirety with the following:

> **(a) General.** When performing "engineering and design" related services, or upon the request of the State or Municipality, the contractor shall carry architects/engineers professional liability insurance covering errors and omissions made during performance of contractual duties with the following minimum limits:
>
> $3,000,000 – Annual Aggregate
> $2,000,000 – Per Occurrence

4.02 GENERAL COMPLIANCE WITH LAWS; RESPONSIBILITY FOR VIOLATION. This section shall be modified as follows by Add at the end of the last sentence:
Including but not limited to the Prequalification of Contractors and Burlington Livable Wage Ordinance as applicable based on the contract value limits set in the Ordinance. The Women's Economic Opportunity Program, Non-Outsourcing Ordinance, and the Union-Deterrence Ordinance shall be applicable to all Contracts with the Municipality except where Federal Highway Association preclude the use of these contracts or the work type is "engineering and design related". The Contractor shall provide the required certifications attesting to compliance with these ordinances.

(a) **City of Burlington Ordinances.** (available online at http://www.codepublishing.com/vt/burlington/)

~~(1) Prequalification of Construction Contractors. As defined by SUBPART B - RELATED LAWS, CHAPTER 21, ARTICLE V - PREQUALIFICATION OF CONSTRUCTION CONTRACTORS, Sec. 21-67 through Sec. 21-78. For all projects where total project cost is one hundred thousand dollars ($100,000.00) or more.~~

(2) City Livable Wages Ordinance. As defined by SUBPART B - RELATED LAWS, CHAPTER 21, ARTICLE VI - LIVABLE WAGES, Sec. 21-80 through Sec. 21-87. For any

contractor that has a service contract(s)with the City of Burlington where the total amount of the service contract or service contracts exceeds fifteen thousand dollars ($15,000.00) for any twelve (12) month period, including any subcontractors of such contractor or vendor.

(3) Women's Economic Opportunity Program. As defined by SUBPART B - RELATED LAWS, CHAPTER 21, ARTICLE II – WOMEN IN CONSTRUCTION TRADES, Sections 21-50 through 21-55. For the projects where the total cost is fifty thousand dollars ($50,000.00) or more.

(4) City Outsourcing Ordinance. As defined by SUBPART B - RELATED LAWS, CHAPTER 21, ARTICLE VII - OUTSOURCING, Sec. 21-90 through Sec. 21-94. For any contract for services which involves any city funds and the total amount of the contract is fifty thousand dollars ($50,000.00) or more

(5) City Union Deterrence Ordinance. As defined by SUBPART B - RELATED LAWS, CHAPTER 21, ARTICLE VIII – UNION DETERRENCE, Sec. 21-100 through Sec. 21-103. For Any contract for services which involves any City funds and the total amount of the contract is fifteen thousand dollars ($15,000.00) or more

7.03 ELECTRONIC DATA MEDIA. Modify (a) with the following:

For Municipal only projects the MPM shall determine the CADD software preference and version.

END SPECIAL CONDITIONS

Appendix A – Owner Supplied Documents

0 125 250 500 Feet

BY _____ DATE _____ PROJECT Burlington, VT SHEET NO. _____ OF _____

CHKD. BY _____ DATE _____ Reservoir Covers JOB NO. 80-062

INDEX

No.	Description	Page
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2	Beam Design - North	2
3	Column Design - North	2 - 5
4	Footing Design - North	5 - 7
5	Wall Design - South	8 - 12
6	Details	13 - 20
7	36" sq. Future Opening - North	21 - 23
8	Louvers - North	24 - 28
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BY D.J.B. DATE 6-19-80 PROJECT Burlington, Vt. SHEET NO. 1 OF
CHKD. BY DATE North Reservoir Cover JOB NO. 0-062

National Building Code 1976

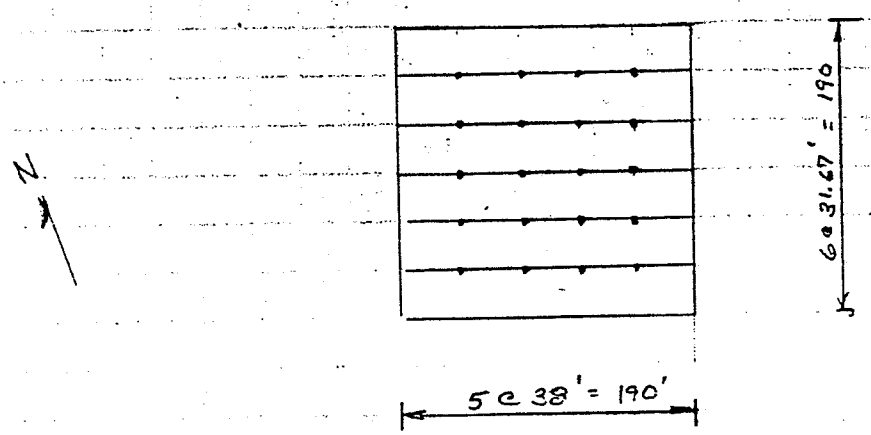
Roof Design

Snow Load

Figure 904.2b = 50 psf

Tar & Gravel = 6 psf

Total = 56 psf.



Spadrete - 10" Plank w/ 2" Topping OK

check feasablity of hollow core over continuous wet condition.
Sevino Ferrandi - Flexacore
& Ed Barwicki - San Val
agree than moisture inside the cores present no problem.
Use hollow-core plank.

Roof - 10" Hollow-core Plank w/ 2" Conc. Topping w/ Tar & Gravel Roof System.

BY D.B. DATE 6.19.80 PROJECT Burlington, VT SHEET NO. 2 OF
CHKD. BY DATE North Reservoir Cover JOB NO. 0-062

Beam Design - beams run east to west

Roof Load = 56 psf
Plank = 101 psf
157 psf

157 psf (31.67') = 4,972 plf = 5 klf

Joe Atzl - San Val Engineer

20" x 30" - Precast Beam

Composite design w/ 10" Plank & 2" Topping

Columns - Working Stress

Loads

Snow load	.05 ksf (31.67')	= 1.58 klf
Tar & Gravel Roof	.006 ksf (31.67')	= 0.19
Plank & Topping	.102 ksf (30.67')	= 3.13
Precast Beam	(1.67')(3.5').15 kcf	= .88
		5.78 klf

5.78 klf (38') = 219.64 K

f_y = 40,000 psi ; f_s = 20,000 psi
f'_c = 3,500 psi ; $n = E_s/E_c = 29{,}000{,}000 / 57{,}000\sqrt{f'_c} = 8.6$
t = 36"

20" beam/2 + 1/2" exp. + 2 1/2" angle edge to c/c bo
+ 5" to c/c bolt to face of conc
= 18" ∴ 18(2) = 36" column.

Assume min steel = 1% A_g = .01(π(18")²) = 10.18
10.18 □"/8 bars = 1.27 □" = ≈ 10
g_t = 36" - [2" cover + .5" spiral + 1.27"/2]2 = 29.7"
$g = g_t/t$ = 29.7/36 = 0.825

$A_g = \pi R^2 = \pi(18)^2 = 1,017.88$ sq. in.

$N = 220$

Wind Load

$A_{wall} = 190' \times 5' = 950$ sq. ft

length height

$\therefore \quad p = q_A C_p - q_M C_{pi}$

$q_A = \frac{(1000 - A)}{800}(q_p - q_F) + q_F$

$= \frac{(1000-950)}{800}(24 - 15) + 15$

$= 15.56 \approx 16$

$= 16(0.8) - 16(0.3) \qquad n = 0$

$= 8$ psf on windward wall

$p = 16(-0.5) - 16(-0.3) \qquad n = 0$

$= -3.2$ psf on leeward wall

$p = q_F\left[C_p \text{ (windward)} - C_p(\text{leeward})\right]$

$= 16\left[0.8 - (-0.5)\right]$

$= 20.8$ psf overturning

$M_w = 20.8 \text{ psf}(32')19.5'$

$= 12.98$ ft-k

$M_{col_{E\text{ to }W}} = 12.98 \text{ ft-k}/6 = 2.16$ ft-k

$M_{col_{N\text{ to }S}} = 12.98/7 = 1.85$ ft-k

$M_{vect_{wind}} = \sqrt{2.16 + 1.85} = 2.00$ ft-k

EARTHQUAKE LOAD

$$V = ZKCW$$

Zone 2 $\therefore Z = 0.50$
$K = 1.00$

$$C = \frac{0.05}{\sqrt[3]{T}}$$

$$T = \frac{0.05\,h_n}{\sqrt{D}} = \frac{0.05\,(22')}{\sqrt{190}}$$
$$= 0.08$$

$$= 0.05 / \sqrt[3]{0.08} = 0.12$$

$$W = [5.78\ \text{klf}\ (190')]6 + [190'(11')(1.67')(.15\ \text{kcf})$$
$$+ [\pi(1.5')^2(19.5)(.15\ \text{kcf})]\,20$$
$$= 9{,}096.89^{k}$$

$$= 0.50\,(1)(0.12)\,9{,}097^{k}$$
$$= 545.82^{k}$$

$$F_t = 0.004\,V\left(\frac{h_n}{D_s}\right)^2$$
$$= 0.004\,(546^{k})\left(\frac{22'}{19.5'}\right)^2$$
$$= 2.78$$

$$M = J\left(F_t h_t + \sum_{i=1}^{n} F_i h_i\right)$$

$$J = \frac{0.6}{\sqrt[3]{T^2}} = 0.6 / \sqrt[3]{(0.08)^2} = 3.23$$

$$= 3.23\,[2.65(22)]$$
$$= 188.31\ \text{ft-k}$$

$M_{col.\ E+W} = 188.31^{Ft-k} / 6 = 31.39^{Ft-k}$

$M_{col\ N+S} = 188.31 / 7 = 26.90^{Ft-k}$

$M_{Vect\ Earthquake} = \sqrt{31.39 + 26.90} = 7.63^{Ft-k}$

$\frac{N}{f'_c A_g} = \frac{220^k}{3.5\ ksi\ (1{,}018\ sq.in)} = 0.06$

$\frac{P_b}{f'_c A_g} = 0.19$ interpolated by Table 30

$\frac{P_b}{f'_c A_g} > \frac{N}{f'_c A_g}$ Tension governs.

Since the reservoir is surrounded by a continuous wall the stiffness of the wall is so much greater no load will go to the columns so no moment will be felt.

Ties:

16 bar ϕ = 16(1.128) = 18.05"
48 ties ϕ = 48(.5) = 24"
least dim = 36"

∴ 36" Columns w/ minimum steel (1%) is more than adequate.

$A_s = .01 A_G = 8.04^{\square''} / 3 = 1.005^{\square''}$

Use 8-#9 w/ #4 Ties @ 16" o.c.

Footing Design - Working Stress

$W_T = 5.78\ klf\ (38') + \pi(1.5)^2(19.5')\ .15\ kcf$
$= 240.32^k$

blow count ave/ft = 49
material - fine & medium sand

BY DJB DATE 6-26-80 PROJECT Burlington, VT SHEET NO. 6 OF
CHKD. BY DATE North Reservoir Cover JOB NO. 0-062

Text : Basic Soils Engineering
by B.K. Hough
second edition

Fig 9-3
Pg. 308

use 8,000 psf for bearing capicity

$$A_{req'd} = \frac{P}{8\ ksf} = \frac{240^k}{8\ ksf}$$

$$= 30\ sq.ft.$$

Sq. Footing $= \sqrt{30} = 5.48'$

use $5'-6'' \times 5'-6''$

Determain min. d (footing depth)

Foundation Engineering Pg. 378

Punching Shear : $$\frac{d}{B} = \frac{\sqrt{4C^2 + 4C + k^2(1 + 4C + 4C^2)} - k(1 + 2C)}{2(1 + C)}$$

$$C = q_n / 576 v_c$$

$$= 8{,}000 / 576 (2\sqrt{f'_c})$$

$$= 0.12$$

$$k = \frac{a}{B} = \frac{36}{66} \qquad \frac{3}{5.5}$$

$$= 0.55$$

$$= \frac{\sqrt{4(.12)^2 + 4(.12) + (.55)^2\left[1 + 4(.12) + 4(.12)^2\right]} - (.55)(1+2(.1$$
$$2\left[1 + (.12)\right]$$

$$\frac{d}{B} = 0.1426$$

$$d_{min} = 0.1426(66'')$$

$$= 9.41''$$

Moment

$$d_{min} = \sqrt{\frac{M}{K}}$$

effective area of cd.

$$M = 8\ ksf\left(\frac{5.5' - \left[3' - (4''(\tfrac{1'}{12''})2\right]}{2}\right)^2 / 2$$
$$= 40.1\ ft\text{-}k$$

$$= \sqrt{40.1/276}$$

$$= 0.62''$$

$F_y = 40{,}000$ psi ; $f'_c = 3{,}500$ psi
$n = 8.6$
$F_s = 20{,}000$ psi ; $f_c = .45\ F'_c = 1575$ psi
$b = 12''$; $d = 9.5''$
$M = 40$ ft-k ; $V = 25^k$

$$A_s = \frac{M}{cd} = \frac{40}{1.44(9.5)}$$
$$= 2.92 \text{ sq. in.}$$
$$A_{s_{TOTAL}} = 2.92(5.5') = 16.08 \text{ sq. in}$$

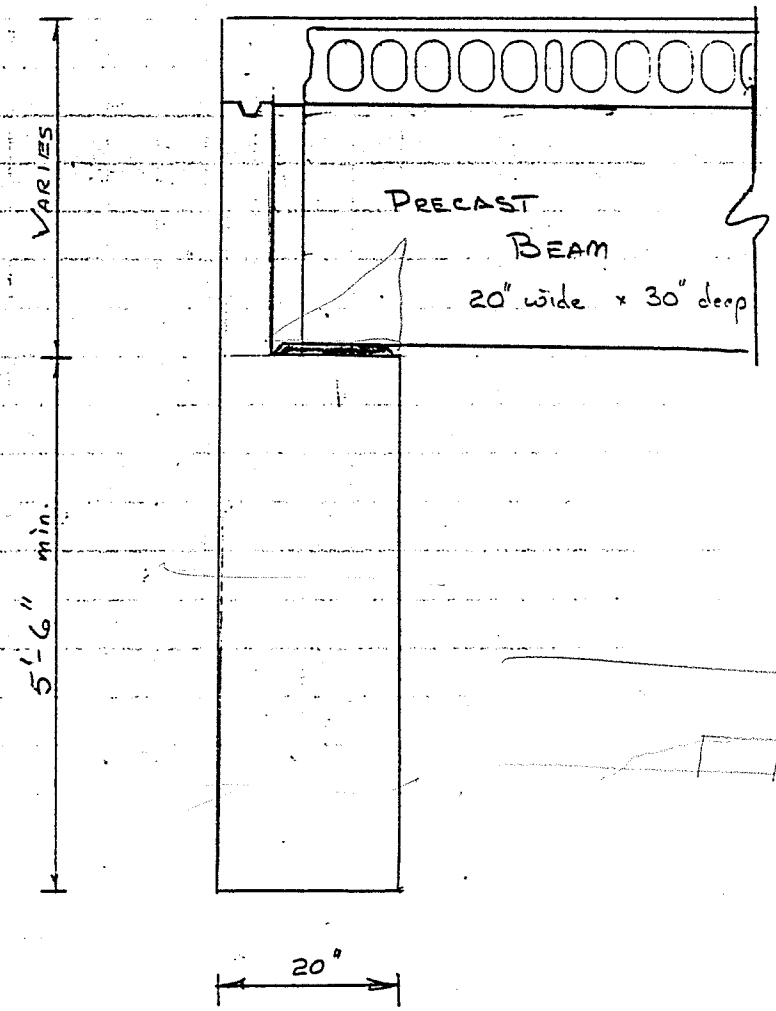
Use #11 $16.08/1.56 = 11$ - #11's = #11 @ 6" o.c. E.W.
Temp. Steel = $.0020 A_g = .0020(12'')^2 = 0.29$ #5 @ 12" e.w.

FOOTING : 5'-6" x 5'-6" x 12" w/ #11 @ 6" e.w. Top
#5 @ 12" e.w. bot.

BY D.J.B. DATE 7-3-80 PROJECT Burlington, Vt. SHEET NO. 8 OF

CHKD. BY DATE South Reservoir Cover JOB NO. 0-062

WALL



Longest Beam (col - wall) = 62'

$$P = 62'/2(5.78\ k/f) = 179.2^k$$

$$\phi P_{nw} = 0.55\,\phi f'_c A_g \left[1 - \left(\frac{l_c}{40h}\right)^2\right]$$

$$= 0.55(.7)\,3500\,[(20")+(20")4](20")\left[1 - \left(\frac{66"}{40(20")}\right)^2\right]/100$$

$$= 2{,}676.66^k \gg 179.2^k \qquad \underline{OK}$$

use : 20" wall

Soil Bearing Capacity (q_a)

Basic Soils Engineering
Pg. 308
Fig. 9-3

Ave blows/ft = 15 in loose fine sand

q_a = 3,000 psf = 3 ksf

Check uniform load from plank

ω_T = 0.158 ksf

ω_L = .158 ksf (16') = 2.53 klf

ω_{TL} = 2.53 klf / 1.67'

= 1.52 ksf < 3 ksf OK

∴ no footing required

Check point load from beam

P_{max} = 179.2 k

h_T = 8'-6"

eff width = 17'

$$\omega_L = 179.2^k / 17' = 10.5 \text{ klf}$$

$$\omega_{TL} = 10.5 \text{ klf} / 1.67 \text{ ft}$$

$$= 6.23 \text{ ksf} > 3 \text{ ksf}$$

∴ footing is required

$$A = \frac{P}{f_c} = \frac{179.2^k}{3 \text{ ksf}}$$

$$= 59.7 \text{ s.f.}$$

$$\text{width} = \frac{A}{l} = \frac{59.7 \text{ s.f.}}{17 \text{ ft.}}$$

$$= 3.5 \text{ ft.} \qquad \text{use } 3.5 \text{ ft.}$$

Punching Shear

$$\frac{d}{B} = \frac{\sqrt{4C^2 + 4C + k^2(1 + 4C + 4C^2)} - k(1 + 2C)}{2(1 + C)}$$

$$C = q_n / 576 \, v_c$$

$$= 3{,}000 / 576 (2\sqrt{f'_c}) = 3{,}000 / 576 (2\sqrt{350}$$

$$= 0.05$$

$$k = \frac{a}{B} = \frac{20''}{3.5'(12'')}$$

$$= 0.48$$

$$= \frac{\sqrt{4(.05)^2 + 4(.05) + (.48)^2[1 + 4(.05) + 4(.05)^2]} - .48(1 + }{2(1 + .05)}$$

$$= 0.08$$

$$d = .08\,B = .08\,(5.5')\,12''/'$$

$$= 15.3''$$

Moment.

$$d_{min} = \sqrt{\frac{M}{K}}$$

$$M = 3\ ksf\left(\frac{3.5-(1.67')}{2}\right)^2 / 2$$

$$= 1.26\ ft\text{-}k$$

$$d_{min} = \sqrt{1.26/.276}$$

$$= 2.13'' < 5.3''$$

USE : d = 12" min for reinf footing (SAG)

$$A_s = \frac{M}{ad} = \frac{1.26}{1.44[12-(3+1)]}$$

$$= 0.10\ sq.\ in\ /\ ft\ width$$

$$\#4\ @\ 24 = 0.10\ \square/ft = 0.10$$ OK

Temp. Steel

$$.0020\,A_G = .002(12')\,12''$$

$$= 0.29\ \square/ft$$

$$\#5\ @\ 12 = 0.31\ \square/ft > 0.29\ \square/ft$$

Continuos Footing 3'-6" x 12" w/ #5 @12 T & B E.W.

20" Wall req's only min. steel for both cases.

Horiz.

$A_{s_{HORIZ}} = .0025\ A_G$

$= .0025\,(12")\,20"$ ← req's 2 layers of steel

$= .60\ \square/ft\ /2$

$= .30\ \square/ft$

$\#5 @ 12 = .31\ \square > 0.30\ \square$ OK

Vert.

$A_{s_{VERT}} = .0015\ A_G$

$= .0015\,(240\ \square)\ /2$

$= .0.18\ \square/ft$

$\#4 @ 12 = 0.20\ \square > 0.18\ \square$ OK

20" Wall w/ #5 @ 12 e.f. Horizontal
#4 @ 12 e.f. Vertical

8" Wall supports plank

snow = .05 ksf
roofing = .006
plank = .102
.158 ksf (32/2) = 2.53 klf

$$\phi P_{nw} = 0.55 \phi F'_c A_g \left[1 - \left(\frac{l_c}{40h}\right)^2\right]$$

$$= 0.55(.7)3500(8")(12")\left[1 - \left(\frac{54"}{40(8")}\right)^2\right]/1000$$

$$= 125.7 \text{ klf} \gg 2.53 \text{ klf}$$ OK

use min. steel

$$A_{s_{HORIZ}} = .0025 A_g = .0025(12")8"$$

$$= 0.24 \square"/ft$$

#5 @ 12 = 0.31 □" > 0.24 □" OK

$$A_{s_{VERT}} = .0015(96 \square")$$

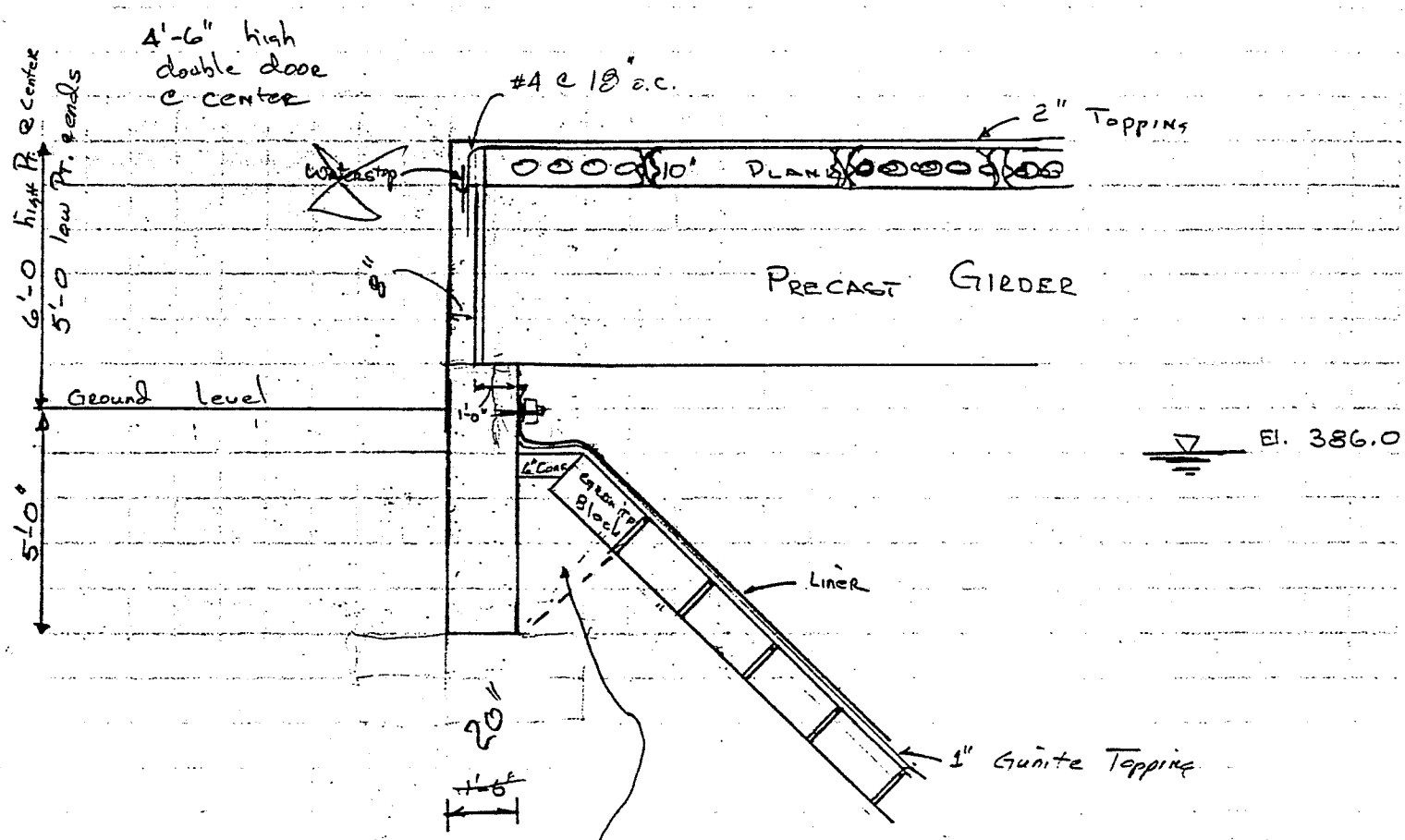
$$= 0.15 \square"/ft$$

#4 @ 12 = 0.20 □" > 0.15 □" OK

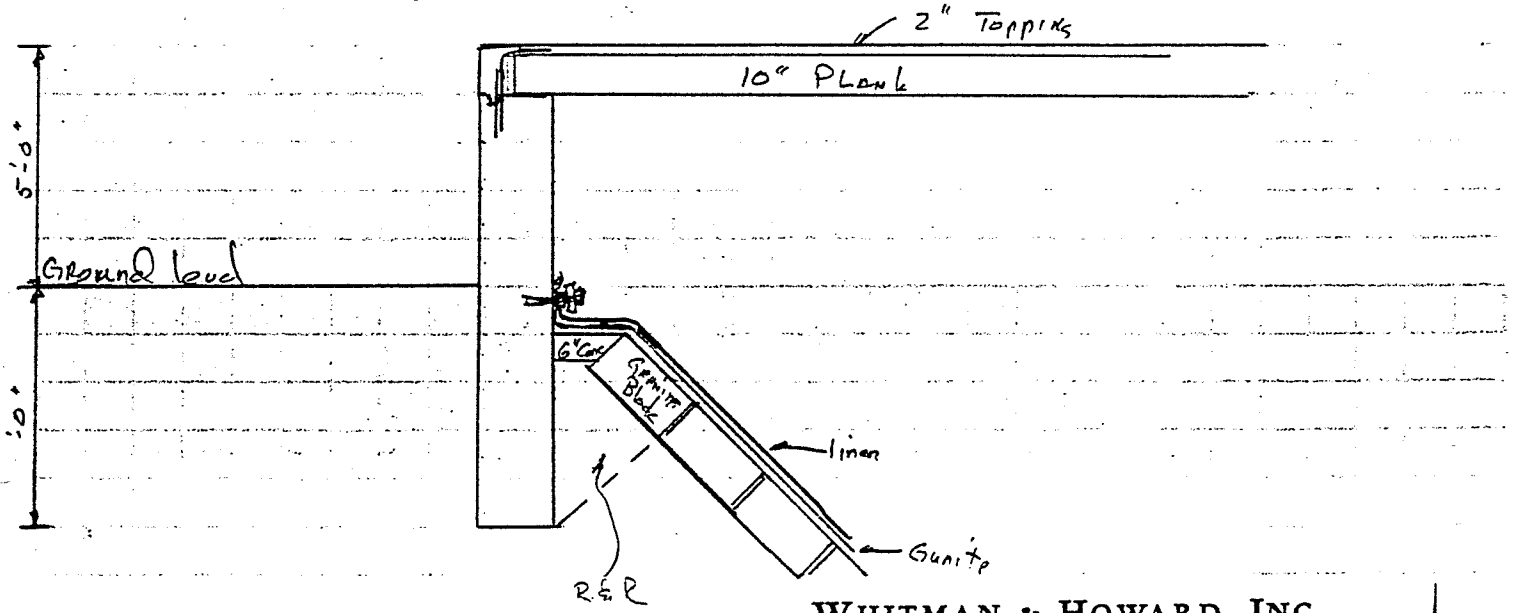
8" Wall w/ #5 @ 12 horz.
#4 @ 12 vert.

BY D.B. DATE 5.17.80 PROJECT Burlington, Vt. SHEET NO. 13 OF

CHKD. BY DATE North Reservoir JOB NO. 0-062



Top Granite Block removed so wall can be constructed. Compacted fill & block replaced. 6" Conc. Cap. installed.

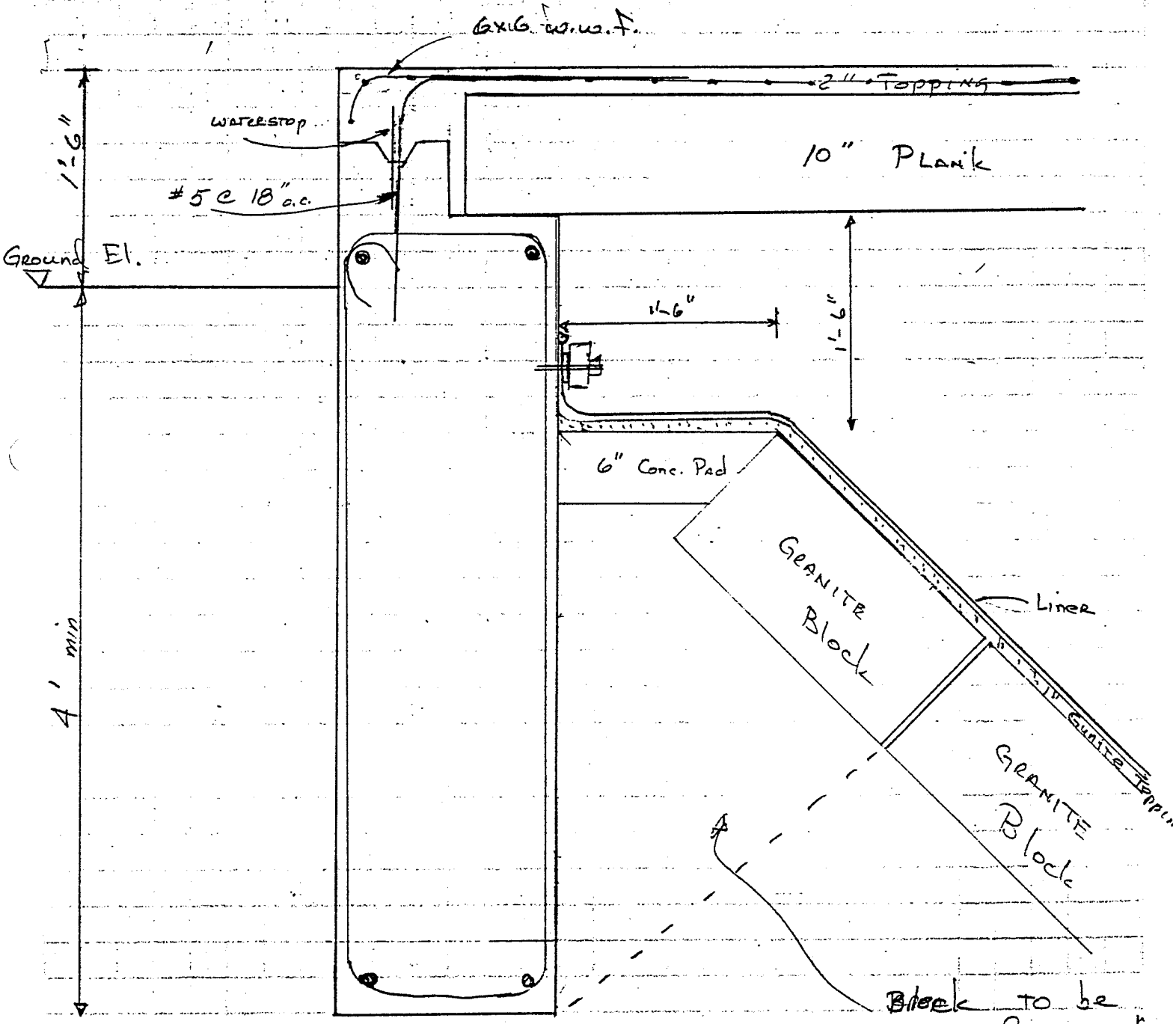


WHITMAN & HOWARD, INC.
45 WILLIAM STREET, WELLESLEY, MASS.
Engineers and Architects

BY _____ DATE _____ PROJECT _____ SHEET NO. 14 OF _____

CHKD. BY _____ DATE _____ JOB NO. _____

4'-6" high door @ high pt.

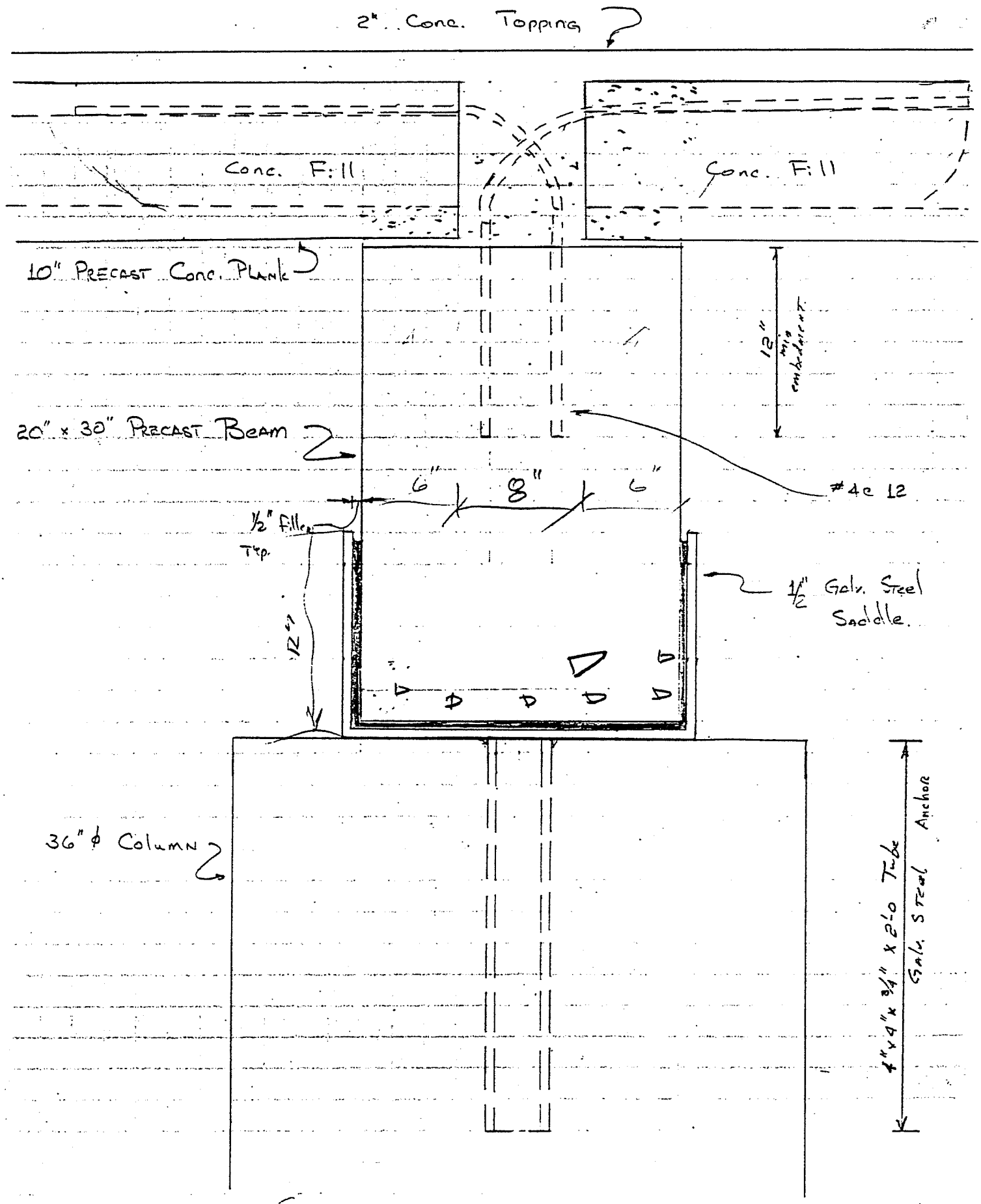


Block to be removed to dig exterior cont. wall fill compacted & block replaced.

WHITMAN & HOWARD, INC.
45 WILLIAM STREET, WELLESLEY, MASS.
Engineers and Architects

BY _____ DATE _____ PROJECT Burlington, Vt. SHEET NO. 15 OF _____

CHKD. BY _____ DATE _____ JOB NO. 0-062

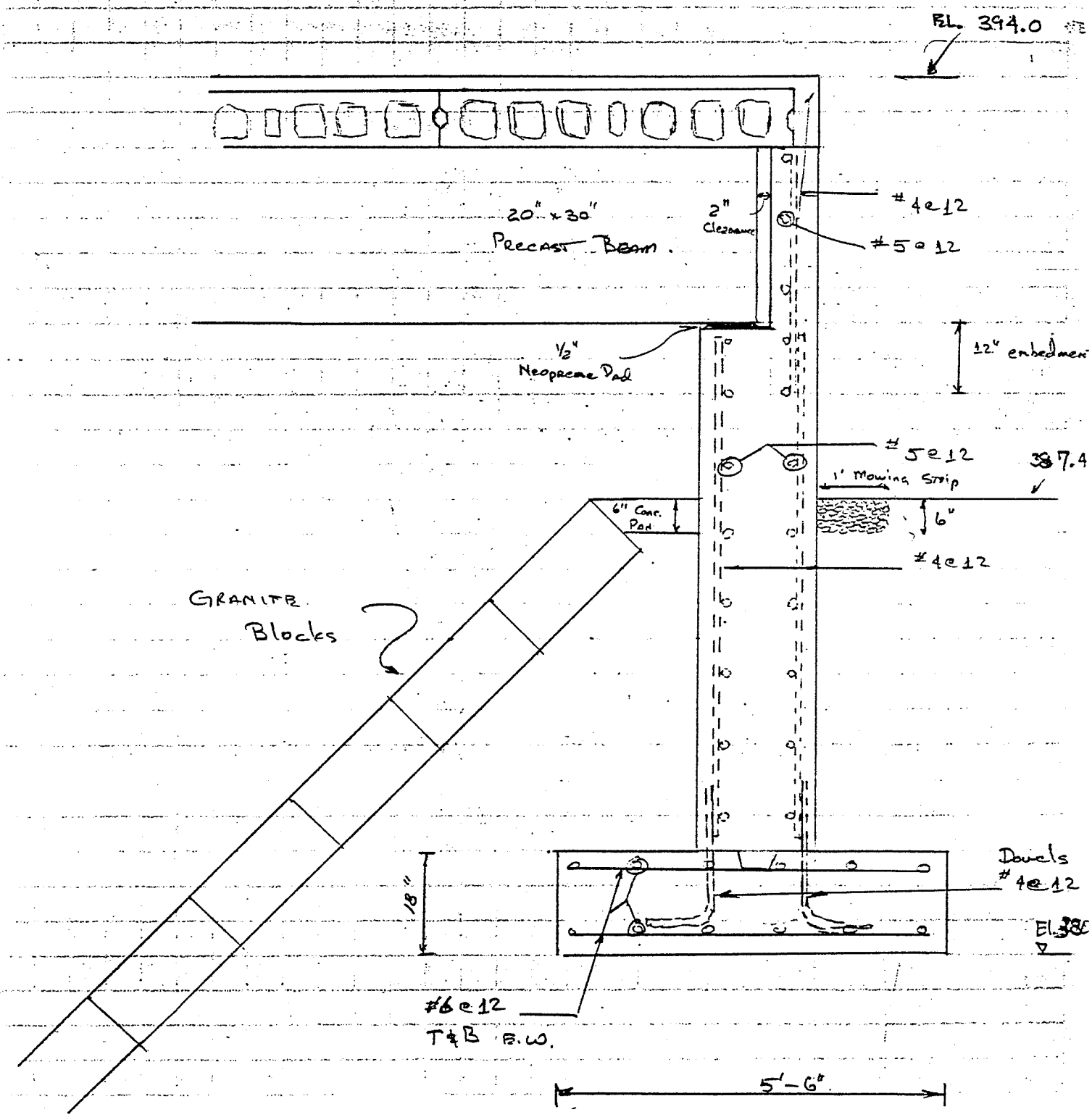


Section
Typ. Beam Connection

WHITMAN & HOWARD, INC.
45 WILLIAM STREET, WELLESLEY, MASS.
Engineers and Architects

BY _____ DATE _____ PROJECT Burlington, VT. SHEET NO. 16 OF _____

CHKD. BY _____ DATE _____ JOB NO. 0-062

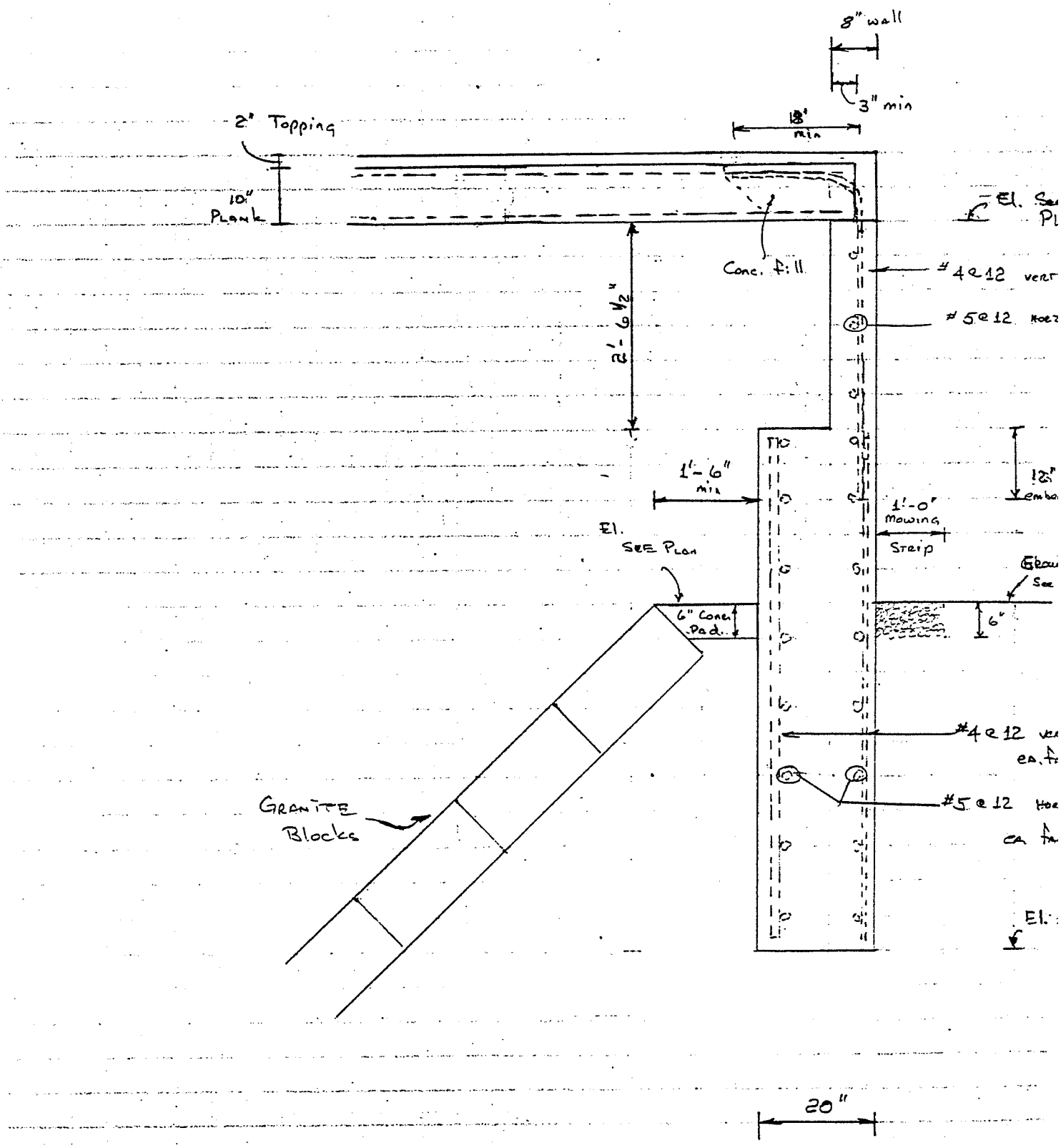


SECT. B-B

WHITMAN & HOWARD, INC.
45 WILLIAM STREET, WELLESLEY, MASS.
Engineers and Architects

BY _____ DATE _____ PROJECT Burlington, Vt SHEET NO. 17 OF _____

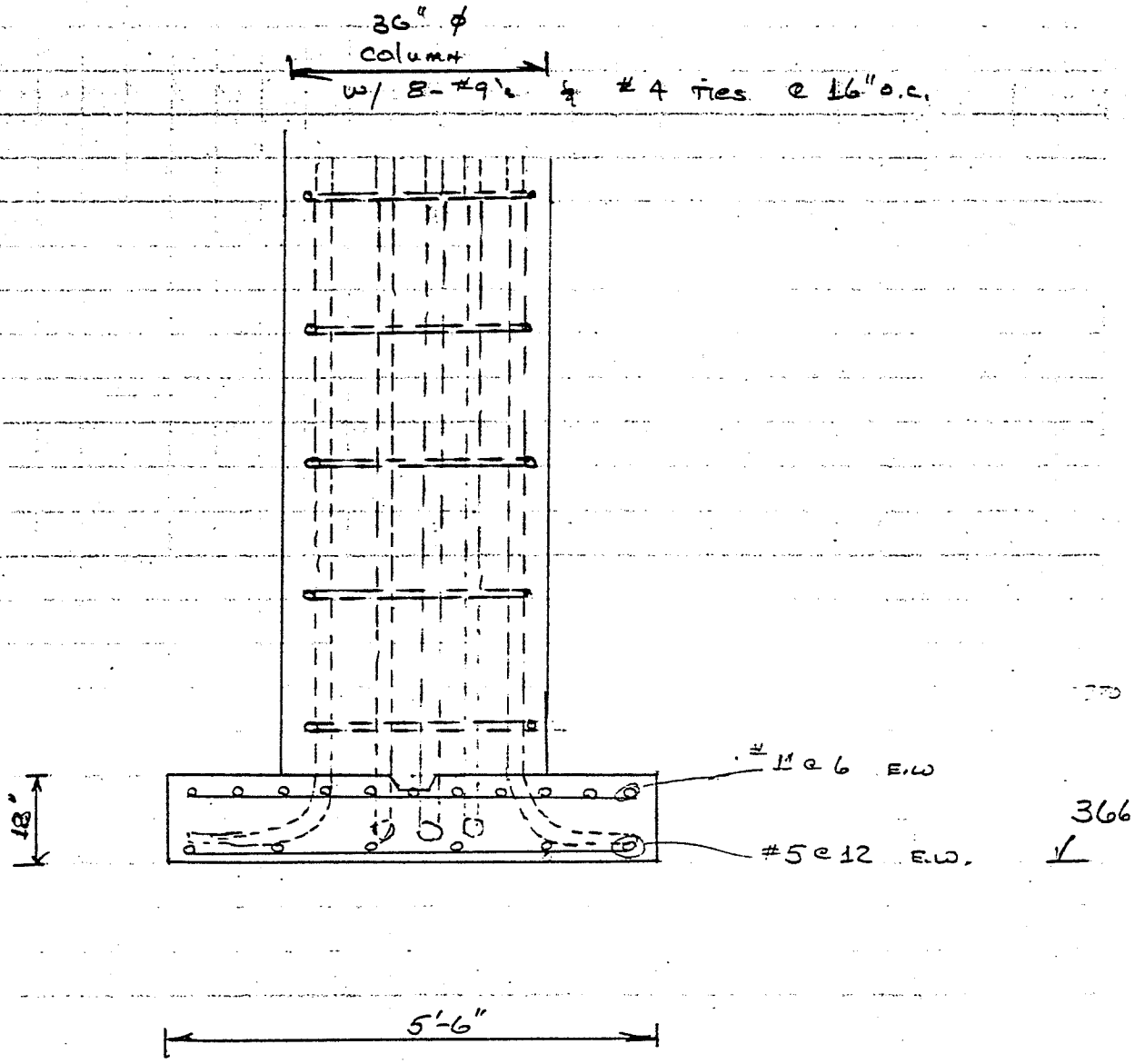
CHKD. BY _____ DATE _____ JOB NO. 0-062



Section A-A

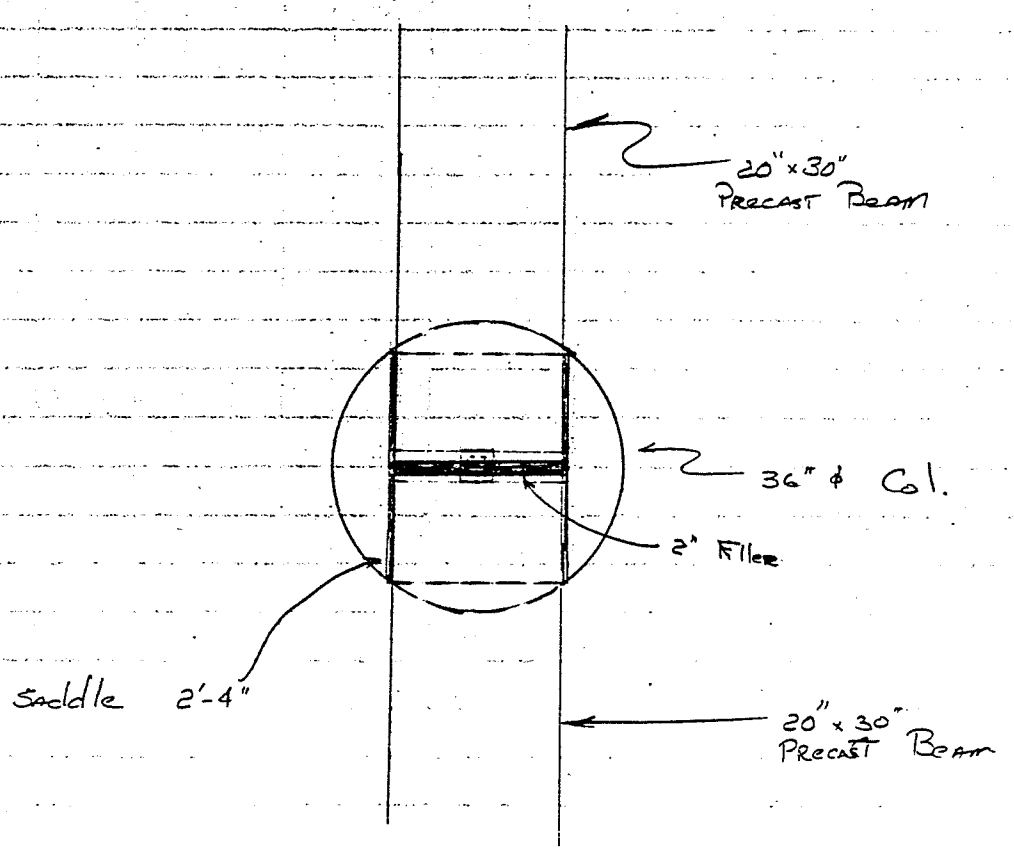
BY _____ DATE _____ PROJECT Burlington, VT SHEET NO. 18 OF _____

CHKD. BY _____ DATE _____ JOB NO. 0-062



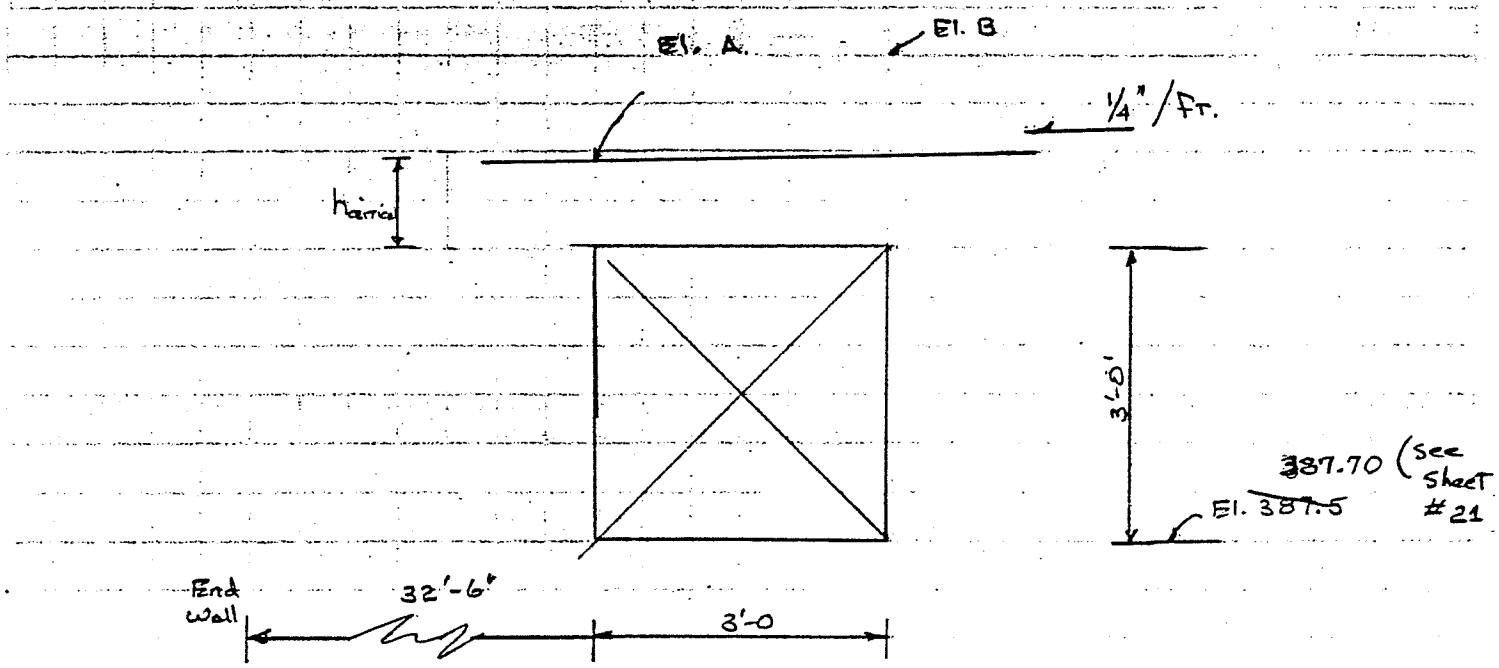
BY _____ DATE _____ PROJECT Burlington, Vt. SHEET NO. 19 OF _____

CHKD. BY _____ DATE _____ JOB NO. 0-062



PLAN

36" Future Opening



El. A < El. B ∴ critical

North H.P. = 394.~~00~~ 5 (see sheet #29

$\ell/2$ = 190.67/2 = 95.33'

North L.P. = 394.~~00~~ 5 − [95.33'(.25"/'/12"/')]

> 392.~~02~~ 52

El. @ Pt. A = 392.~~02~~ 52 + [32.5'(.25"/'/12"/')]

= ~~392.70~~ 393.20

∴ $h_{critical}$ = ~~392.70~~ 393.20 − [387.5 + 3]

= 2.~~20~~ 70' = 2'-~~2~~ 8 3/8"

$h_{Beam} = 2.\overset{8}{\cancel{2}}0' - 1'$ ← Plank & Topping

$= 1.\overset{8}{\cancel{2}}0 = 1'-\overset{8}{\cancel{2}}3/8''$

Raise Block Elev. $\overset{8}{\cancel{2}}3/8''$ to keep it off ground as much as possible.

$\therefore$ El. $= 387.5 + 0.\overset{7}{\cancel{2}}0$

$= \overset{388.20}{\cancel{387.70}}$

$h_{Beam} = 1'-0''$

$\therefore d_{eff} = 12'' - (3/4'' + .875)$ ← Clearance, ← 1/2 #6 + #4B

$= 10.375''$

$\approx 10''$

Conc. Lintel Beam

Main Steel

$b = 8''$ $d = 10''$

$\omega_T = 2.53$ klf $+ .15$ klf (1)

← See Sheet 12

$= 4.03$ klf

$V = \frac{\omega l}{2} = \frac{4.03 \text{ klf } (4')}{2}$

$= 8.06^k$

$$M = \frac{wl^2}{8} = \frac{4.03 \text{ klf } (4')^2}{8}$$

$$= 8.06 \text{ ft-k}$$

$$F = \frac{bd^2}{12000} = \frac{8(10)^2}{12000}$$

$$= 0.0667$$

$$M - KF = 8.06 - [274(.0667)]$$

$$= -10.2158$$ neg ∴ no compression steel required

$$A_s = \frac{M}{ad} = \frac{8.06 \text{ ft-k}}{1.44(10)}$$

$$= 0.56 \text{ ▥}$$

$$A_{s_{min}} = \rho bd = .005(8)10$$

$$= 0.40 \text{ ▥}$$

$2 - \#5$'s $= 0.62$ ▥ > 0.56 ▥ OK

$2 - \#4$'s $= 0.40$ ▥ $= 0.40$ ▥ OK

Shear Reinforcement

$$V_c = 2\sqrt{f'_c}\, b_w d = 2\sqrt{3500}\,(8'')10''$$

$$= 9,466^{\#} > 8,060^{\#}$$ use min ▥'s

$$A_v = 50 \frac{b_w s}{f_y}$$

$$s < d/2 < 18''$$

$s = 10/2 = 5'' < 18''$

$= 50 \frac{8(5)}{40,000}$

$= 0.05 \square$

$\#4 \square = 0.20 \square > 0.05 \square$ OK

Developement length

$l_{devel.} = 1.4[.0004 d_b f_y] = [.0004(.5)3500]\,1.4$

$= 0.98'' \approx 1''$

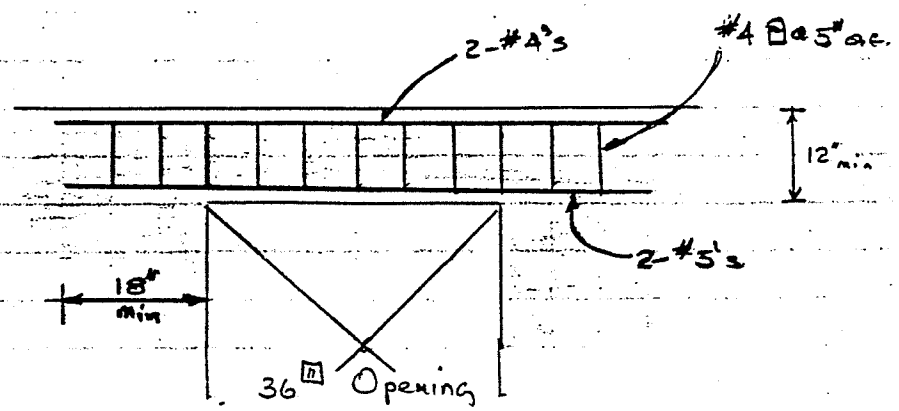
$l_{devl} = 12 d_b = 12(.5'')$

$= 6''$

$l_{devl} = 1/16\ s = 1/16(4)12''$

$= 3''$

$l_{devl_{min}} = 12''$



BY GOES DATE 7/15/20 PROJECT Burlington, VT SHEET NO. 1 OF 1

CHKD. BY ____ DATE ____ Reservoir Covers JOB NO. 0062

Ventilation

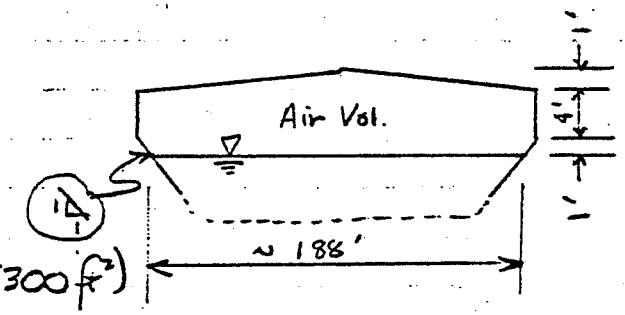
Calculate Area of louvres & vents Needed for natural draft ventilation.

Assume – 6 air changes per hour
Air velocity of 500 ft/min Through vent

North Reservoir

$A = 36{,}100\ ft^2$

$ht = 5ft - 4ft$



$V = 4.5 \times 36{,}100 + 1 \times (35{,}300\ ft^2)$

$V = 197{,}750\ ft^2$

$Q = V \div 10 = 19{,}775\ ft^3/min$

$A = Q \div 500 = 39.55\ ft^2$ or $\underline{\underline{40\ ft^2}}$ for both vents & louvres

South Reservoir

$A = 44{,}800\ ft^2$

Assume configuration similar to No. Res for simplicity.

$ht = 5ft - 3'\text{-}9\tfrac{1}{2}''$

$V = 4.4 \times 44{,}800 + 1 \times (43{,}950\ ft^2)$

$V = 241{,}070\ ft^2$

$Q = V \div 10 = 24{,}107\ ft^3/min$

$A = Q \div 500 = 48.2\ ft^2$ or $\underline{\underline{50\ ft^2}}$ for both vents & louvres

Louvers

North Reservoir

Free Area = 40 ft^2

See Gass Cal. Sheet 1 of 1 7/14/80

Assume 1 - opening / quarter point

∴ total of (3/side) 4 = 12

minus 1 - door & 1 - future opening

∴ Total louvers = 10

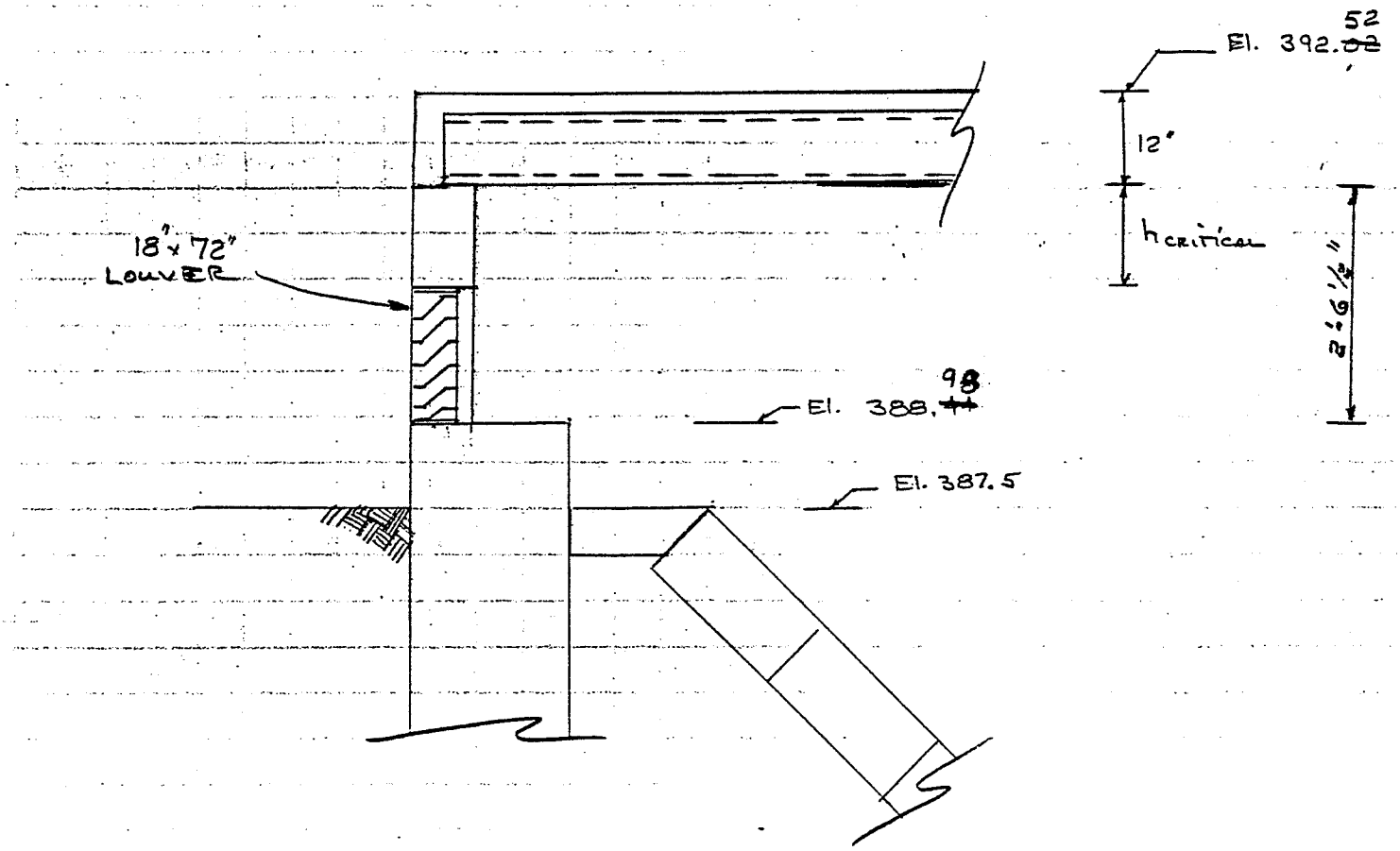
Free Area / louver = $40\ ft^2 / 10 = 4\ ft^2$

Size 18" × 60" = [4.75 + 2.08]/2/1.09
= 3.13 < 4 N.G.

18 × 72" = [5.72 + 2.51]/2/1.09
= 3.78 ≈ 4 OK

BY D.J.B. DATE 10.8.80 PROJECT Burlington, VT. SHEET NO. 25 OF

CHKD. BY DATE North Reservoir Cover JOB NO. 0-062



$$h_{critical} = [392.\cancel{02}\,52 - 1] - [388.\cancel{44}\,98 + 1.5]$$

$$= 391.\cancel{02}\,52 - \cancel{389.94}\,390.48$$

$$= 1.0\cancel{8}\,4 = 1'-\cancel{1}\,1\tfrac{1}{2}''$$

Assume $h_{crit.} = 12''$

$$\therefore d = 12'' - [\tfrac{3}{4}'' + .875'']$$

clearance

$\frac{1}{2}$ #6 + #4 ☐

$$= 10.375''$$

$$\approx 10''$$

Conc. Lintel Beam

Main Steel

$b = 8"$ $d = 10"$

$w_T = 4.03$ klf see Sheet 21

$$V = \frac{4.03^{klf}(7')}{2}$$

$$= 14.11^{k}$$

$$M = \frac{4.03\,klf\,(7')^2}{8}$$

$$= 24.68^{ft\text{-}k}$$

$$F = 0.0667$$

$$M - KF = 24.68 - (274).0667$$

$$= 6.40$$ positive ∴ compression steel is required

$$\frac{d'}{d} = \frac{.75}{10} = .075$$

$$0.333 + 0.667\frac{d'}{d} = .333 + .667(.075)$$

$$= 0.383 < 0.40$$

$$\therefore C = \frac{f_s(2n-1)(1-\frac{d'}{d})(k-\frac{d'}{d})}{12000\,n(1-k)}$$

$$= \frac{20000\,[2(8.51)-1](1-.075)(.4-.075)}{12000\,(8.51)(1-0.4)}$$

$$= 1.5720$$

$$A_s' = \frac{M - KF}{cd}$$

$$= \frac{6.40}{1.572\,(10)}$$

$$= 0.41^{\square}$$

$2 - \#4_s' = 0.40^{\square} \approx 0.41^{\square}$ $b_{min} = 6.5''$

$3 - \#4_s' = 0.60^{\square} > 0.41^{\square}$ $b_{min} = 8.5''$

$2 - \#5_s' = 0.62^{\square} > 0.41^{\square}$ $b_{min} = 7.0''$

$$A_s = \frac{M}{ad}$$

$$= \frac{24.68}{1.44\,(10)}$$

$$= 1.71^{\square}$$

$2 - \#9_s' = 2.00^{\square} > 1.71^{\square}$ $b_{min} = 8.0''$

Shear Reinforcement

$$V_c = 9{,}466^{\#} < 14{,}110^{\#}$$

$$V' = V - V_c$$

$$= 14{,}110 - 9{,}466^{\#}$$

$$= 4{,}644$$

$$A_v = \frac{V'_s}{f_s d}$$

$$\therefore s = \frac{A_v f_s d}{V'}$$

BY DLB DATE 10.8.80 PROJECT Burlington, Vt. SHEET NO. 28 OF

CHKD. BY DATE North Reservoir Cover JOB NO. 0-062

Assume #4

$$s = \frac{.2\,(20{,}000)\,10}{4{,}644}$$

$$= 8.61''$$

$s_{min} = 5''$ See Sheet 23

Developement length

$$\ell_{devel} = 1.4\left[.0004\, d_b f_y\right] = 1.4\left[.0004(1.128)\,3500\right]$$

$$= 2.21''$$

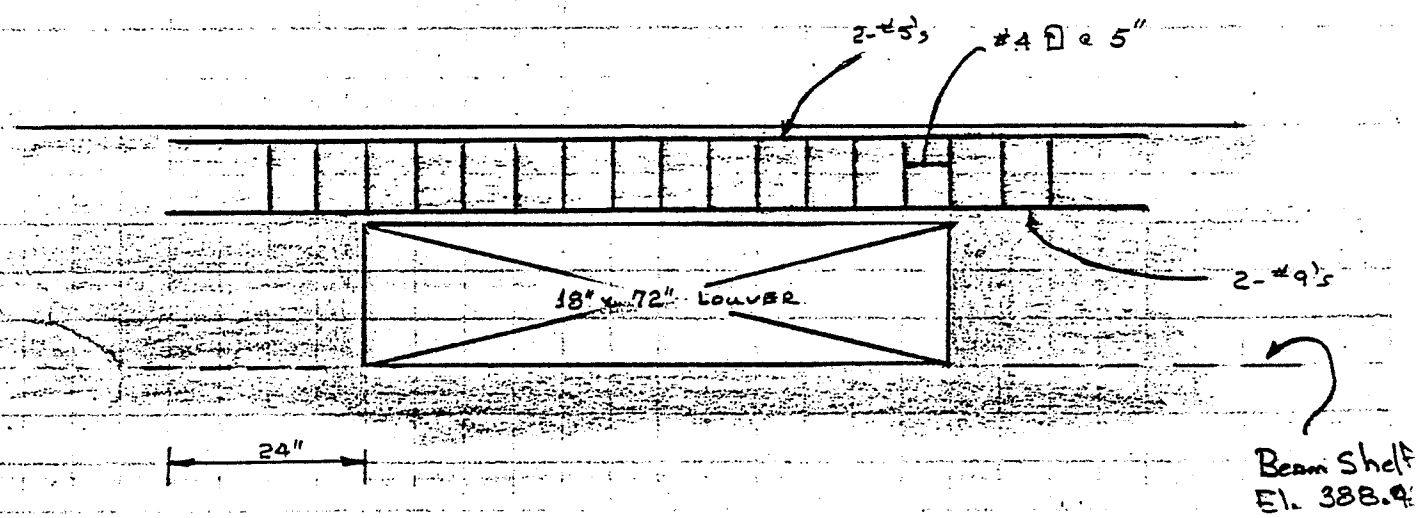
$$\ell_{devel} = 12\, d_b = 12\,(1.128'')$$

$$= 13.54''$$

$$\ell_{devel} = 1/16\ s = 1/16\,(7')\,12''/'$$

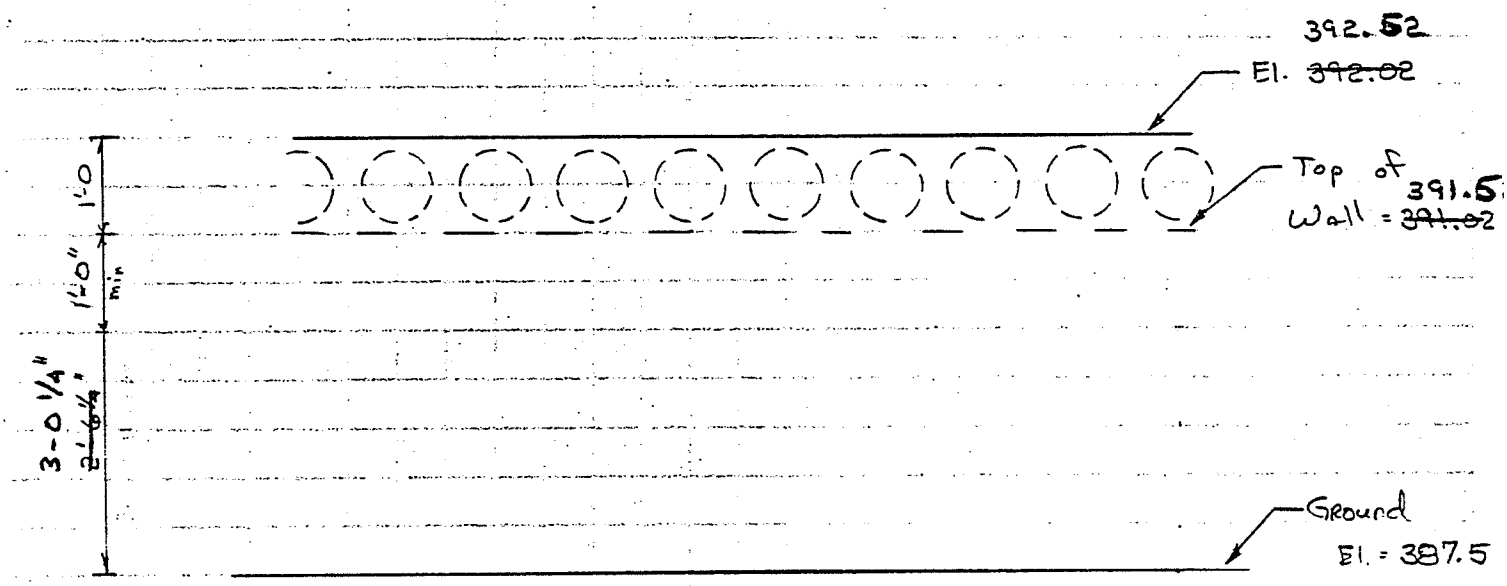
$$= 5.25''$$

$$\ell_{devel_{min}} = 12''$$



BY DJB DATE 10-9-80 PROJECT Burlington, Vt. SHEET NO. 29 OF
CHKD. BY DATE North Reservoir Cover JOB NO. 0-062

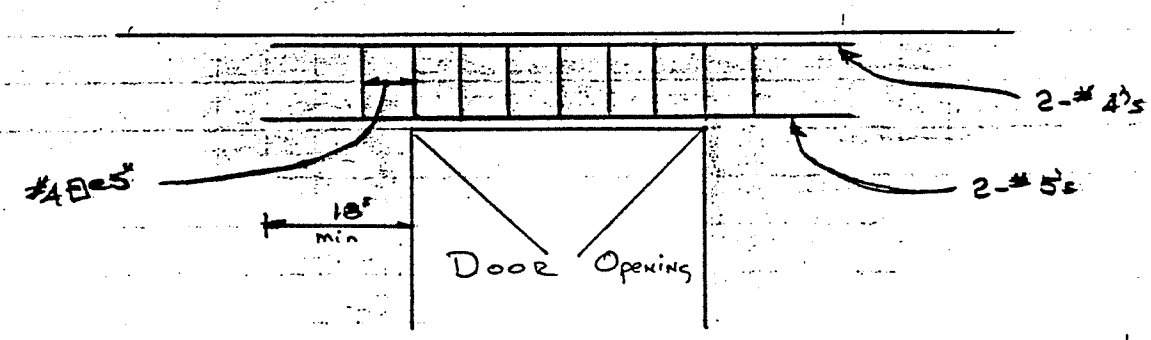
Access Door



Raise minimum elev. by 6" to allow 3'-0 x 3'-0 door.

Conc. Lintel Beam

Same design as for "Future 36" sq. Opening" See Sheets 20 - 23



L.P. = 392.52 same as North to allow for 3'-0 high Access Door.

Set H.P.

$$H.P. = 392.52 + (127.17')(.25\%)/12\%$$

$$= 395.18$$

Access Door

See Sheet 29

Louvers

Free Area = 50 ft^2 See Goss Calcs. 7/14/80

Assume same size as North Reservoir See Sheet 24

$$18'' \times 72'' = 3.78\ ft^2$$

$$\#_{req'd} = 50/3.78$$

$$= 13.2 \approx 13 \text{ Louvers}$$

Since L.P. is same for both

The Beam Shelf is the same

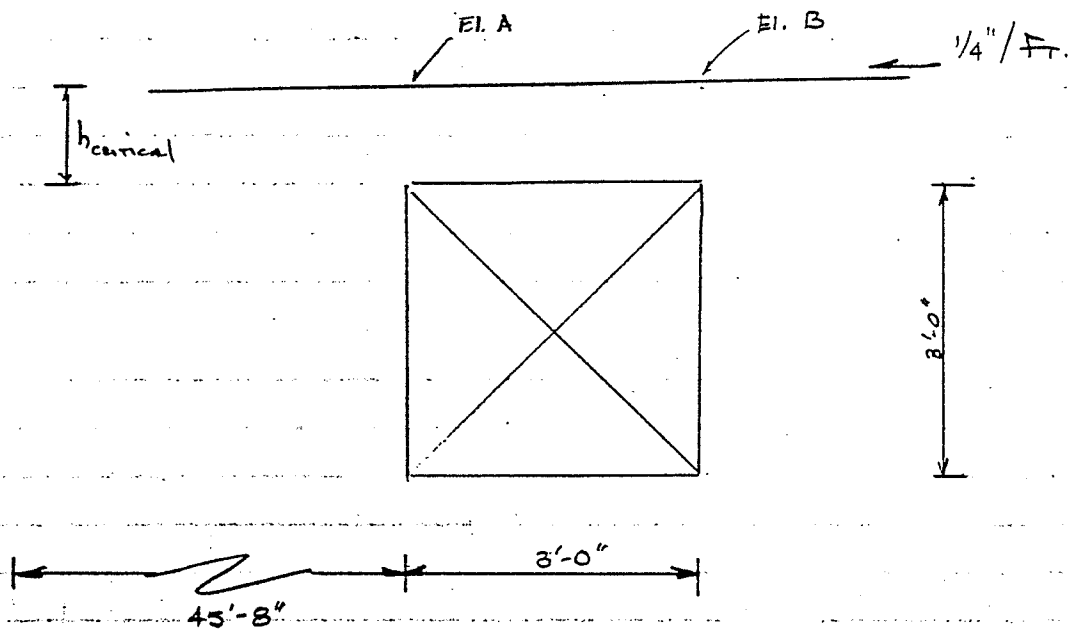
∴ Louver is same

See Sheets 25 - 28

Note Louver @ Far N.E. of Line (F)

the h_{beam} would be less than 12" However load from planks is extremly less than design.

36" Future Opening



South L.P. = 392.52

El. @ Pt. A = 392.52 + (45.67')(.25"/ft)/12"

$= 393.47$

$\therefore h_{critical} = 393.47 - [387.5 + 3]$

$= 2.97' = 2'-11\frac{5}{8}''$

$h_{beam} = 2.97' - 1$

$= 1.97' > 1.80$ See Sheet 21

$\therefore$ Conc. Lintel Beam same

See Sheets 21 - 23

VENTILATORS

Allowable opening 4' by Flexicore design & spec. book.

Approved by AC.

"Cook Gravity Ventilation" catalog

$T_{max} = 48$

∴ Cat No. 36

Free Area = 7.366 ft²

$\#_{South} = 50 ft^2 / 7.366 ft^2$

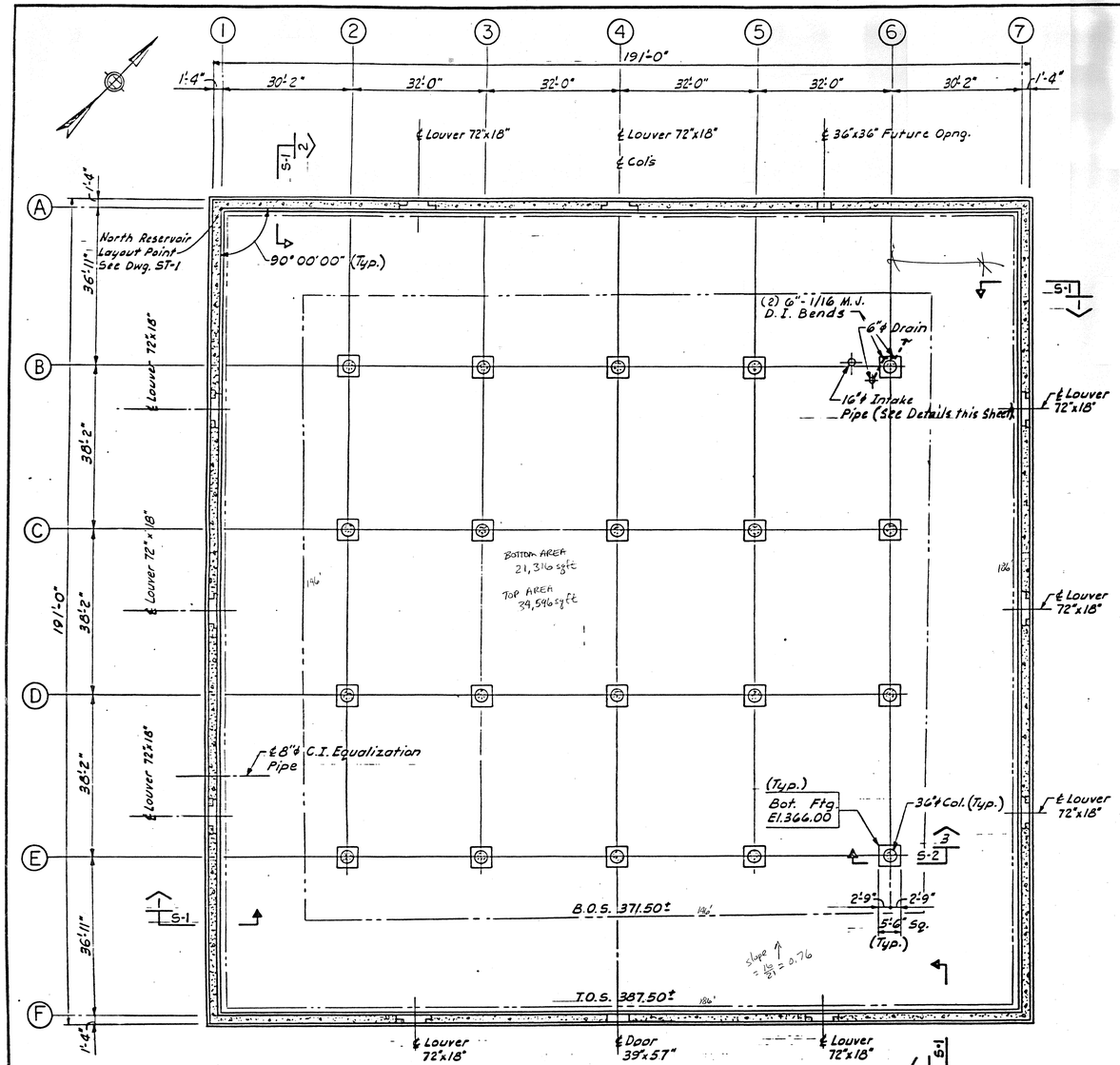
$= 6.8 \approx 7$ units - South

$\#_{North} = 40 / 7.366$

$= 5.4 \approx 6$ units - North

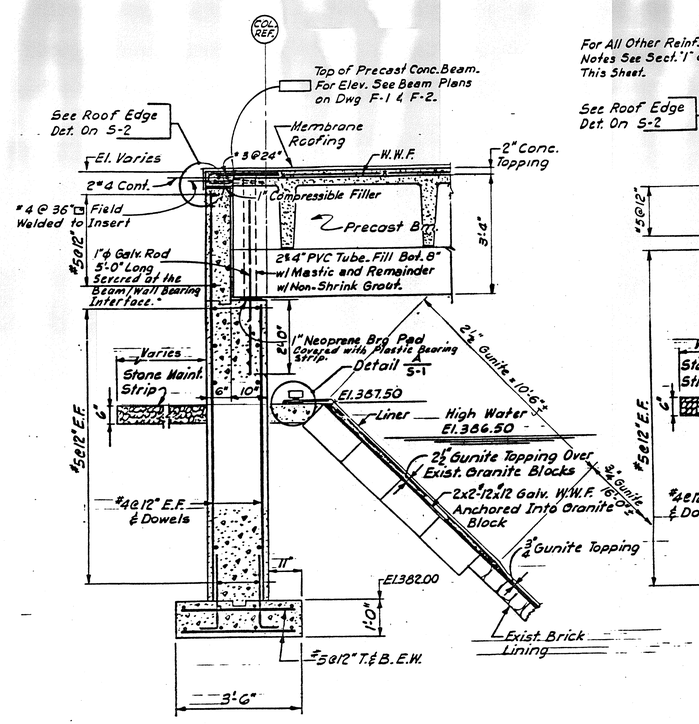
Cat No. 36

Base 48" × 48"
Dome 64 1/8" ϕ

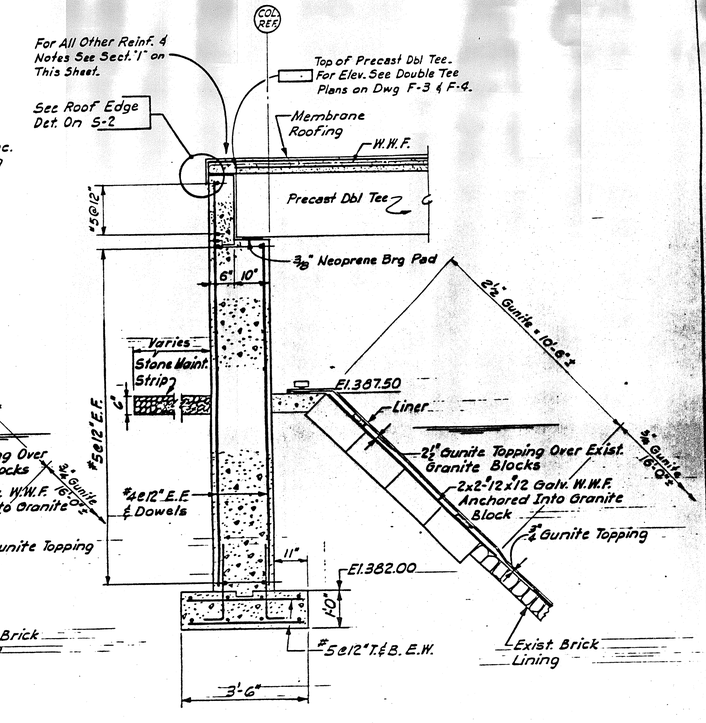


FOUNDATION PLAN
Scale: 1/16" = 1'-0"

WTH 1971: Full mark on gage at reservoir is 382' above MSL

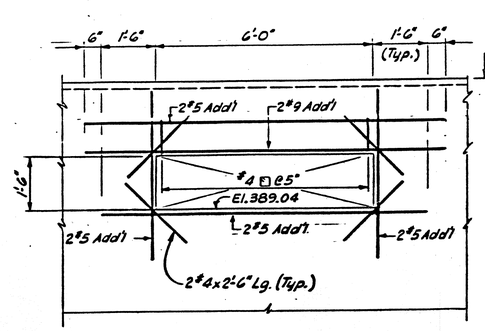


SECTION 1 S-1, S-3, F-3 & F-4
Scale: 1/2" = 1'-0"

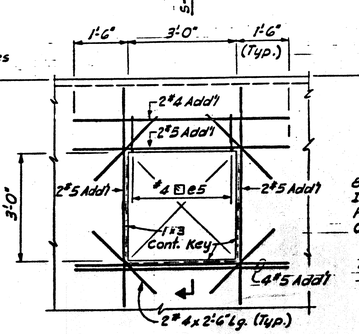


SECTION 2 S-1, S-3, F-3 & F-4
Scale: 1/2" = 1'-0"

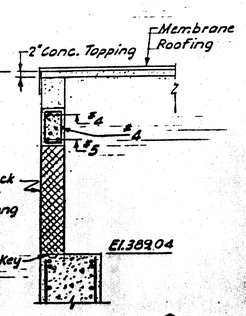
386.50
371.75
14.75



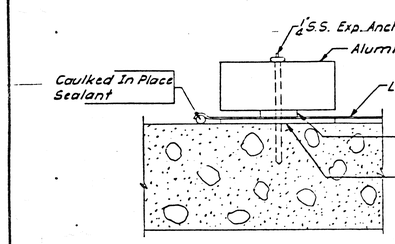
TYP. LOUVER REINF. DETAIL
Scale: 1/2" = 1'-0"



TYP. FUTURE OPNG. REINF. DETAIL
Scale: 1/2" = 1'-0"

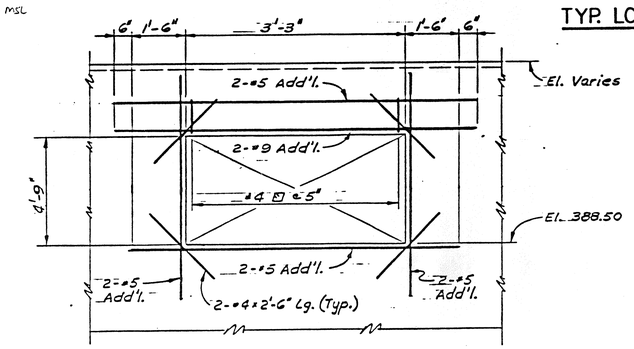


SECTION A S-1
Scale: 1/2" = 1'-0"

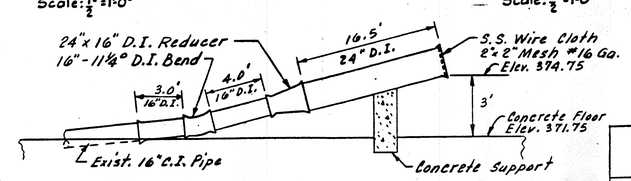


DETAIL A S-1
N.T.S.

Note:
Place A Piece Of Caulking Tape Under The Batten Strip At The Anchor Point. The Butyl Tape Will Seal The Hypalon When The Batten Strip Is Anchored



TYP. DOOR REINF. DETAIL
Scale: 1/2" = 1'-0"



NEW 16"x24" INTAKE DETAIL – NORTH RESERVOIR
N.T.S.

RECORD PLAN

S-1

RESERVOIR COVERS AND LINERS

NORTH RESERVOIR FOUNDATION PLAN & DETAILS

CITY OF BURLINGTON, VERMONT

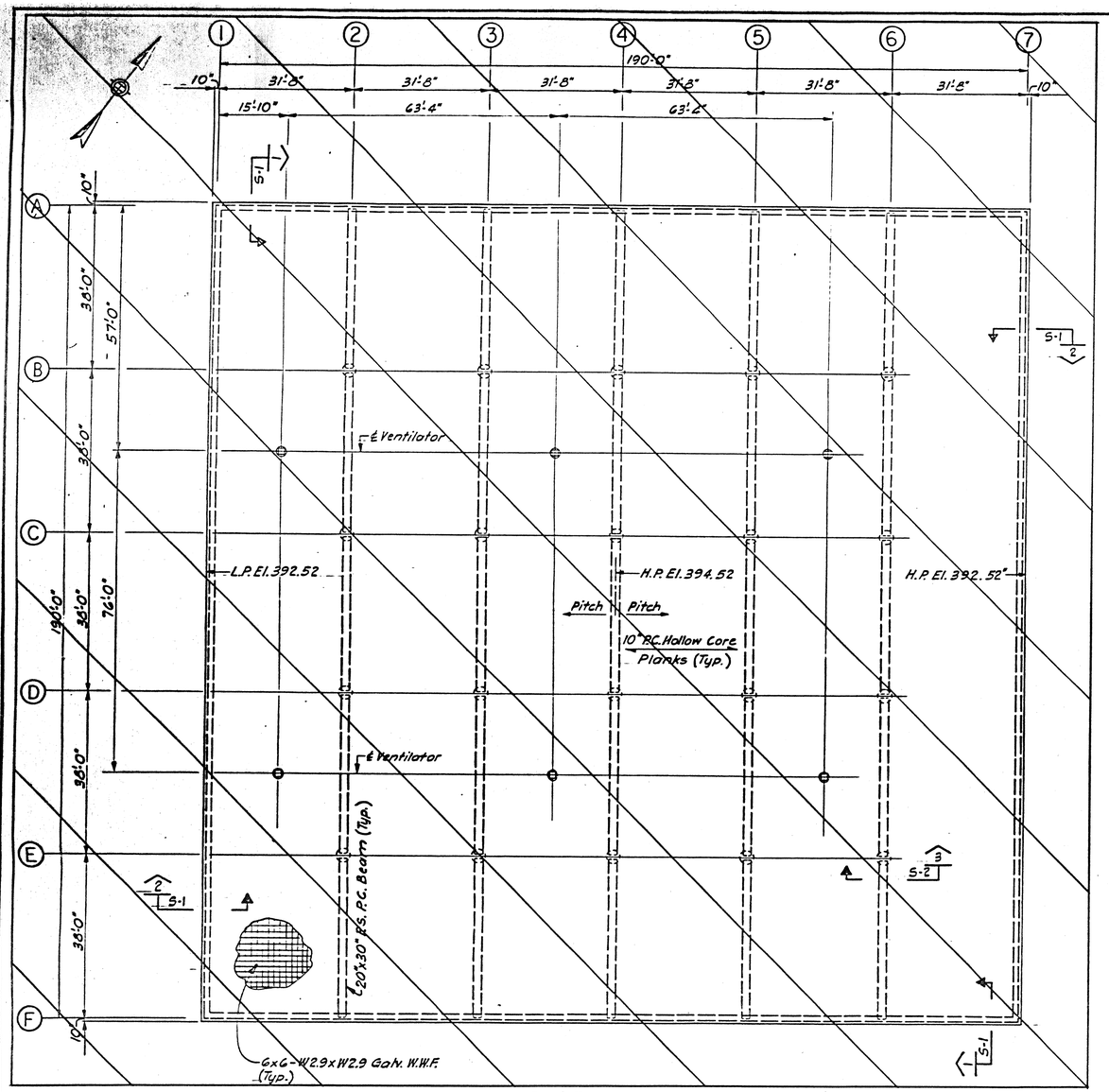
NO.	DESCRIPTION	DATE
	REVISIONS	

REGISTERED PROFESSIONAL ENGINEER ANTHONY CHIARAVELOTTI No. 2716 STATE OF VERMONT

STATE OF VERMONT JOSEPH GOSS No. 3752 REGISTERED PROFESSIONAL ENGINEER

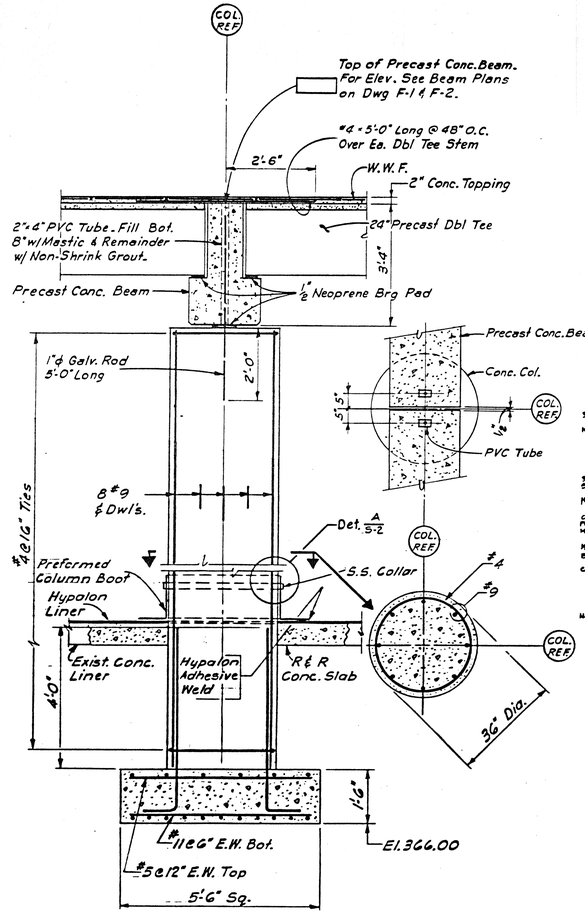
WHITMAN & HOWARD INC.
ENGINEERS AND ARCHITECTS
45 WILLIAM ST. WELLESLEY, MASS.

DESIGNED BY D. J. B.	SCALE AS NOTED	DATE MAY, 1981
DRAWN BY E.W.	APPROVED	
CHECKED BY D. J. B.	JOB NO. 80-062	SHEET 3 OF 7 SHEETS

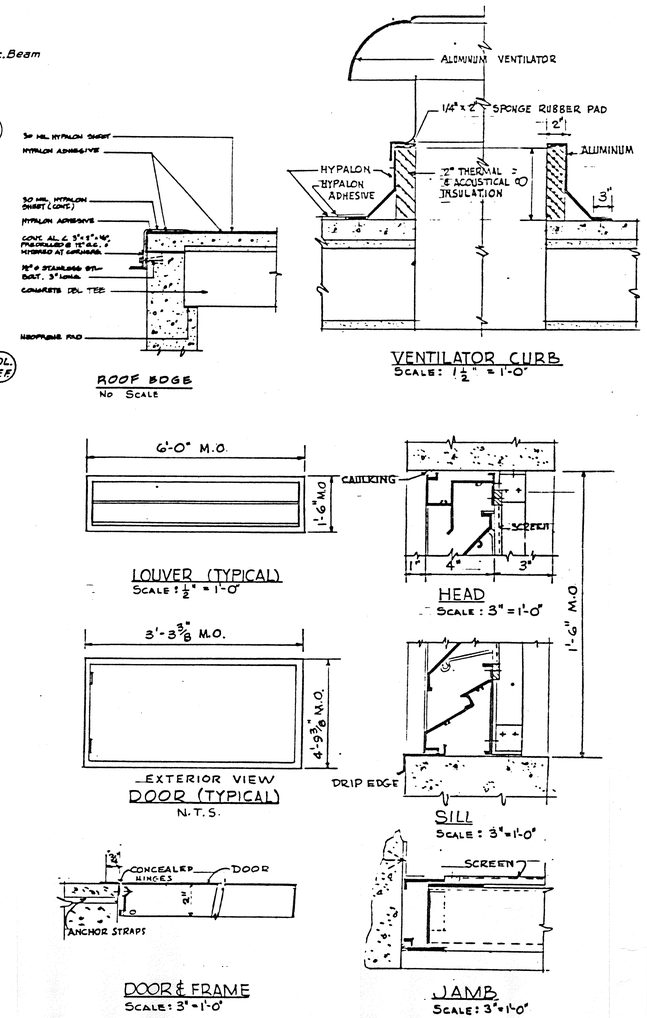


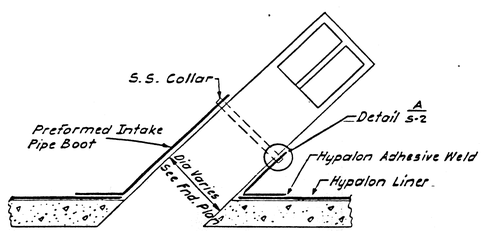
ROOF PLAN
Scale: 1/16" = 1'-0"

For Roof Framing See Dwg F-2 & F-4

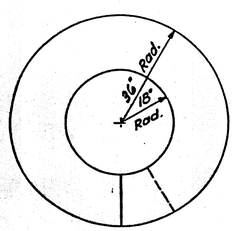


SECTION 3/S-1, S-3, F-3 & F-4
Scale: 1/2" = 1'-0"

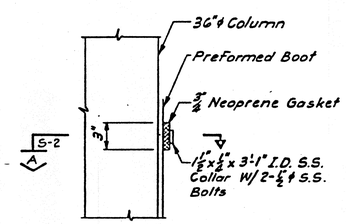




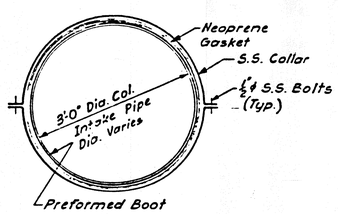
INTAKE & EQUALIZATION PIPE DET.
Scale: 3/4" = 1'-0"



PREFORMED COL. BOOT
Scale: 1/2" = 1'-0"



DETAIL A/S-2
Scale: 1 1/2" = 1'-0"



SECTION A/S-2
Scale: 3/4" = 1'-0"

RECORD PLAN

S-2

RESERVOIR COVERS AND LINERS

NORTH RESERVOIR ROOF PLAN & DETAILS

CITY OF BURLINGTON, VERMONT

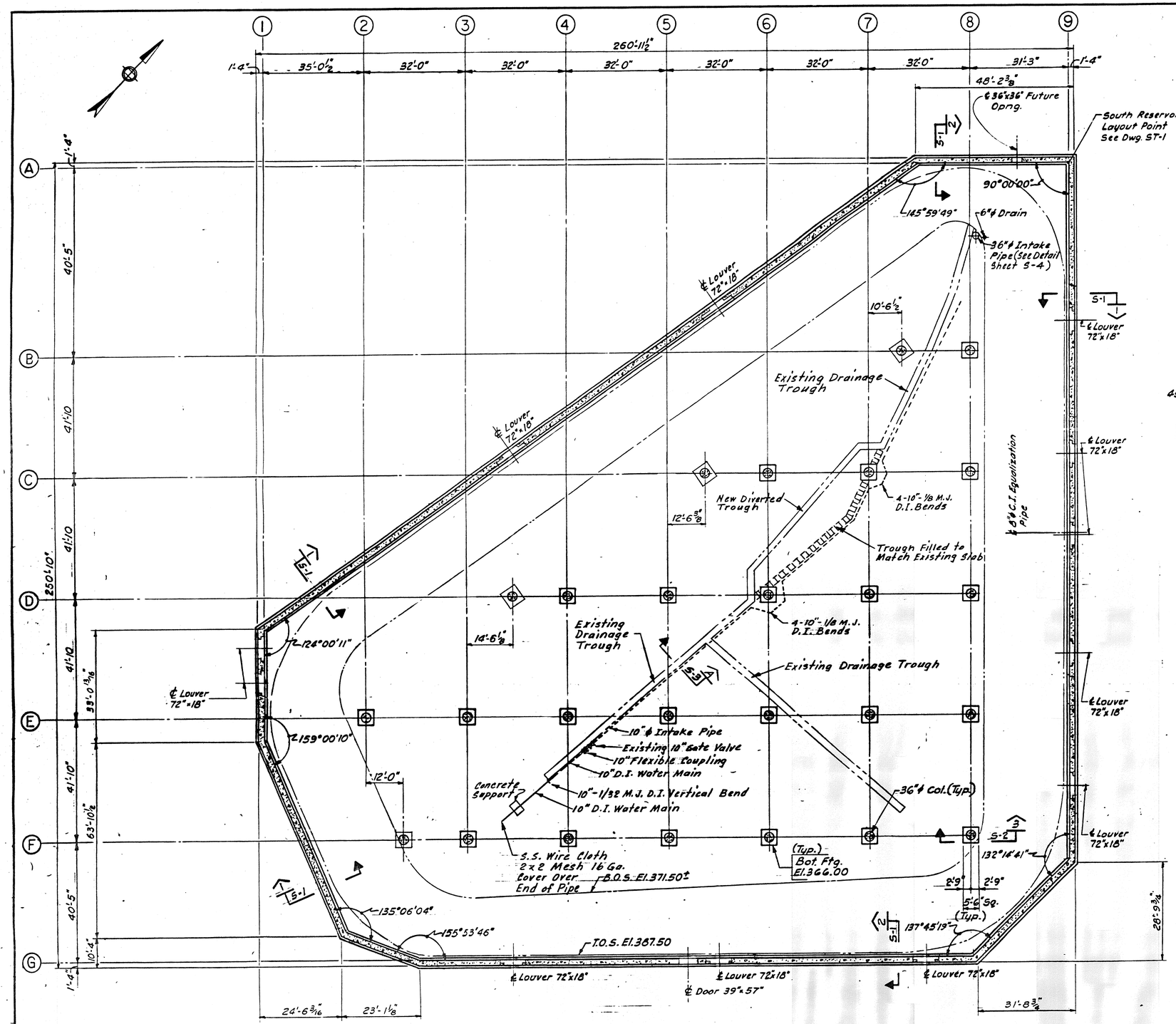
NO	DESCRIPTION	DATE
	REVISIONS	

REGISTERED PROFESSIONAL ENGINEER ANTHONY CHIAPPELLOTTI No. 2716 STATE OF VERMONT

STATE OF VERMONT JOSEPH GOOD No. 3762 REGISTERED PROFESSIONAL ENGINEER

WHITMAN & HOWARD INC.
ENGINEERS AND ARCHITECTS
45 WILLIAM ST. WELLESLEY, MASS.

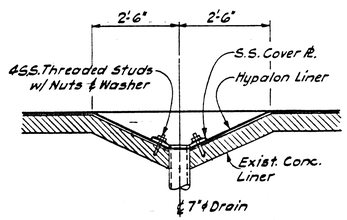
DESIGNED BY	SCALE	DATE
D.J.B.	AS NOTED	MAY, 1981
DRAWN BY E.W.	APPROVED Joseph Good	
CHECKED BY D.J.B	JOB NO. 80-062	SHEET 4 OF 7 SHEETS



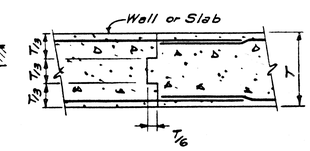
FOUNDATION PLAN
N.T.S.

CONCRETE PROTECTION FOR REINFORCEMENT (a)				
MEMBER		EXPOSED TO		
		AIR	WEATHER & AIR OVER LIQUID	EARTH & LIQUID
FOOTING				3"
WALL COLUMN BEAM		1½"	2"	2"(b)
SLAB	TOP	1½"(c)	2"	2"
	BOTTOM	¾"	2"	2"(b)

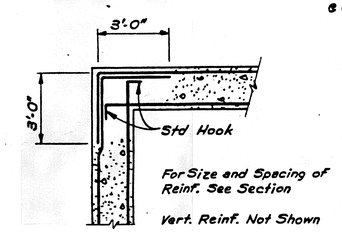
(a) Applicable to All Cast-in Place Concrete Except as Otherwise Shown on The Drawings.
(b) Increase 1" When Cast Against Earth.
(c) ¾" When Membrane or Wearing Surface Used



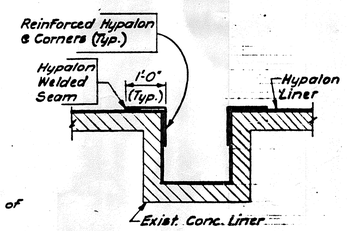
TYP. DRAIN DETAIL
N.T.S.



CONST. JOINT DETAIL
N.T.S.



CORNER REINF. DETAIL
N.T.S.



SECTION A S-3
Scale: ½"=1'-0"

RECORD PLAN

S-3

RESERVOIR COVERS AND LINERS

SOUTH RESERVOIR FOUNDATION PLAN & DETAILS

CITY OF BURLINGTON, VERMONT

NO.	DESCRIPTION	DATE
	REVISIONS	

REGISTERED PROFESSIONAL ENGINEER ANTHONY CHIARAVIOTTI No. 2716 STATE OF VERMONT

STATE OF VERMONT JOSEPH GOSS No. 3762 REGISTERED PROFESSIONAL ENGINEER

WHITMAN & HOWARD INC.
ENGINEERS AND ARCHITECTS
45 WILLIAM ST. WELLESLEY, MASS.

DESIGNED BY D.J.B.	SCALE AS NOTED	DATE MAY, 1981
DRAWN BY E.W.	APPROVED Joseph Goss	
CHECKED BY D.J.B.	JOB NO. 80-062	SHEET 5 OF 7 SHEETS

Capstone Design Project

Water Storage Facility Green Roof for City of Burlington

Community Partner: Steve Roy P.E., Burlington Public Works

Instructors: Dr. Mandar M. Dewoolkar and Dr. Andrea Pearce

Team Members:

Christopher Hale-Sills, Daniel Hammerberg, Jessie Johnson, Katie Kreis & Alexander Sampson

Civil and Environmental Engineering

The University of Vermont

Burlington, VT 05405

January 27, 2015

EXECUTIVE SUMMARY

The City of Burlington's Department of Public Works requested a report to determine the viability of installing a green roof on the top of the city's drinking water reservoirs that are located off from Main Street across from The University of Vermont's main campus. The main issue that needed to be mitigated was the large amount of runoff seen from the impermeable roof surfaces during rainstorms. A green roof design is one method of solving the problem at hand, as well as providing other sustainable benefits. Sustainable benefits include all aspects of modern engineering practice; social, economic, environmental, resiliency, and regulatory.

Careful acquisition of all available background information was needed for this project to succeed. This included a sufficient amount of research to determine which plants and other green roof components would be most appropriate for this specific site.

A hydrologic analysis was performed to compare existing runoff conditions to anticipated runoff from different green roof soil depths. It was found that runoff at the site could be reduced by almost 50% if an extensive green roof with soil depth of 6 inches was installed on the reservoir roofs. Unfortunately, the structural analysis concluded that a green roof should not be installed on either reservoir because the double tee beams in the structures cannot support any additional load. The green roof design cases were developed with the idea that there are other viable sites for which the information would be useful.

LIMITATIONS

The intent of this report is to present the data collected, evaluations, analysis, design, and cost estimates for the Water Storage Facility Green Roof project. The work presented here was performed as a 15-week long project as part of the CE 175 Senior Capstone Design Course, instructed by Professors Mandar Dewoolkar and Andrea Pearce. Although we have exercised the utmost care while working on all components of this project, the reader should be aware that the work was performed within a short time period and with limited resources. This work was directed and reviewed by Professors Dewoolkar and Pearce, other UVM faculty, and external evaluators. However, it has not been formally reviewed by an engineer with a professional licensure from Vermont. The reader is advised that before referencing any part of this report, the work presented here must be independently evaluated by a qualified Professional Engineer.

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1 INTRODUCTION

1.1 OVERVIEW

The City of Burlington Public Works Department manages two covered drinking water reservoirs located near the University of Vermont's main campus adjacent to Main Street. Having a combined impervious area of approximately two acres, the surfaces of the reservoirs contribute significant amounts of stormwater runoff onto Main Street and into the city's combined sewer-stormwater system. Because of this, the excessive, but relatively clean runoff is treated with the raw sewage at Burlington's main Waste Water Treatment Plant, an inefficient use of the plant's energy and resources. The large volume of runoff contributes to combined sewer overflows during storm events, thus aiding to the Lake Champlain's pollution (State of Vermont, 2003). Further, the Watershed Management Division of the State of Vermont Agency of Natural Resources and the U.S. Environmental Protection Agency will soon implement regulations limiting stormwater runoff, and phosphorus loading from existing developments, which include the reservoirs. Currently, storm runoff volumes from the reservoirs may prove to be in violation of future regulations, and as a result the Burlington Public Works Department is considering ways to reduce the site's runoff volume.

The motivation behind this project was to provide a method of reducing the runoff load by installing a green roof onto the unused roof surface of the reservoirs. Green roofs have been successful in reducing stormwater runoff in urban environments by slowing runoff rates which reduces peak flows. They also retain rainwater, thereby decreasing runoff volumes through evapotranspiration of the stored water back into the atmosphere (Luckett, K. 2009)(Dunnett, N., and Kingsbury, N. 2008). Additionally, these roofs can filter rainwater by removing toxins and can also be a resource for urban wildlife. The possible drawbacks of a green roof included the additional load that it would apply to the existing structure, maintenance, and installation cost. Nevertheless, by stepping towards the future of sustainable development and installing a green roof onto the Main Street reservoirs, the site has the potential to reduce runoff, meet ensuing regulations, and form a valuable partnership with its surrounding community by helping Burlington become a green city.

1.2 PROJECT LOCATION AND DESCRIPTION

The reservoirs are located in Burlington Vermont, with one side bordering Main Street between University Terrace and University Place. Figure 1.1 shows the location within the city of Burlington, and Figure 1.2 shows a close-up of the entire property boundaries. The site houses two large drinking water reservoir tanks that serve the city of Burlington. The tanks, and the acres of land surrounding them, are owned and maintained by the City of Burlington Department of Public Works (DPW). Initially built in 1981, both of the tanks contain roughly 14 million gallons of clean drinking water. Both reservoirs are located on an artificial rise of land surrounded by grass and trees, which border the property, as seen in Figure 1.2.

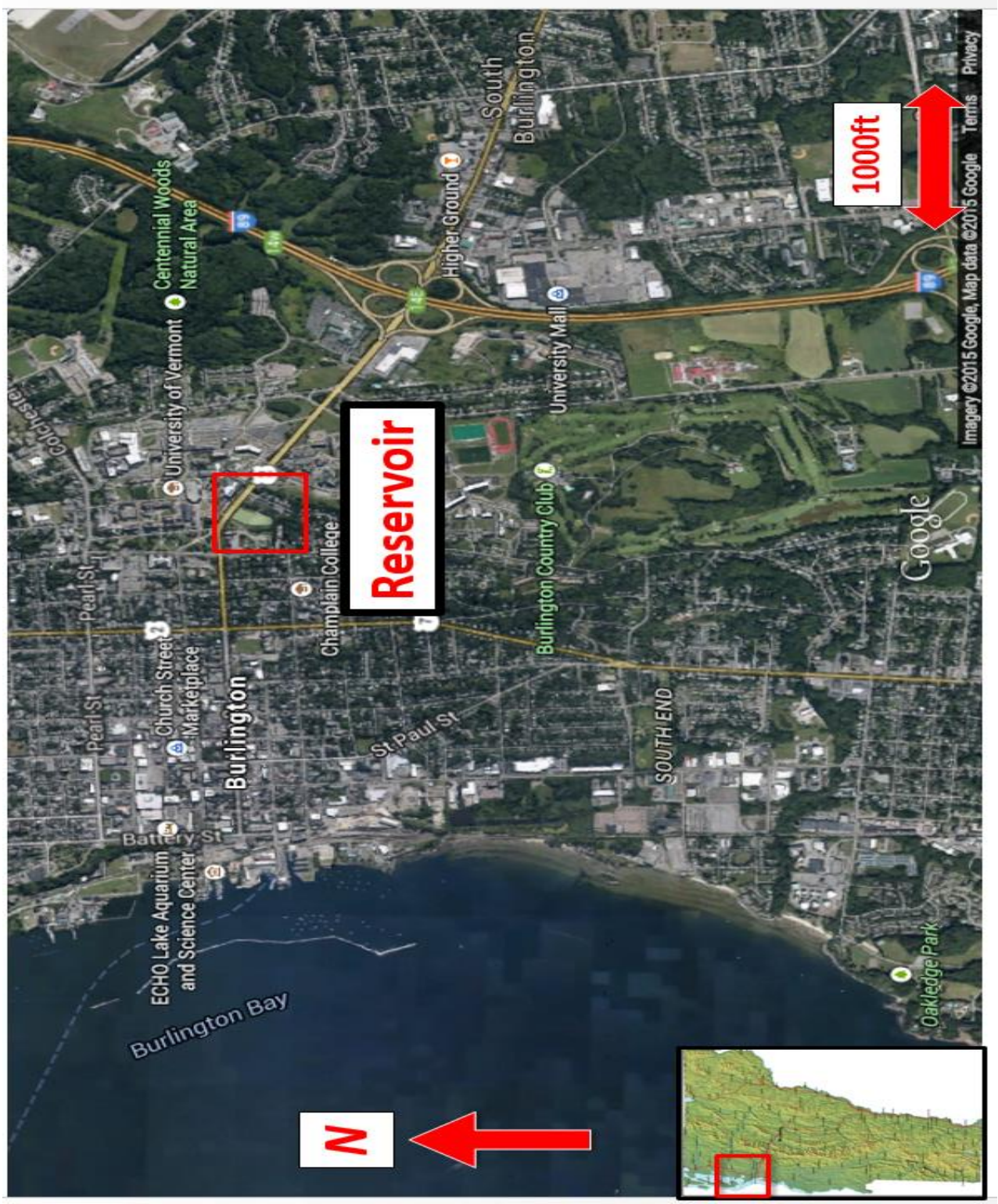


Figure 1.1 Aerial view of site location within the City of Burlington.

Figure 2.2 Aerial view of city property limits of site.

1.3 MAIN OBJECTIVES

The main objectives of this project included:

- Performing an analysis of current structures to establish any necessary improvements and to verify whether or not a green roof is a viable option considering the structure's load capacity.
- Generating green roof designs that are economical and low maintenance which reduce peak flows and runoff volumes entering the city's combined water-sewer system.
- Performing a hydrologic analysis to ensure the green roof designs can properly treat and retain runoff at the site.
- Exploring alternative designs involving retention ponds and/or rain gardens.

1.4 SCOPE OF WORK

The following work was completed for this project:

1) Visited the proposed site, and met with community partner Steve Roy representing the Burlington DPW.
2) Researched the potential options for green roof design including but not limited to:
   a) Aiken center (tray method)
   b) DC green roof company (4" soil fill method)
3) Performed a structural analysis of the Main Street water reservoir roofs.
4) Performed runoff, and hydrologic site analysis.
5) Developed design alternatives.
6) Analyzed the different green roof design approaches including:
   a) Do nothing
   b) Soil fill green roof
   c) Green roof plant trays
   d) Full roof coverage versus partial roof coverage
7) Performed a cost analysis of the different approaches.
8) Determined sustainability of each approach.
9) Researched necessary permitting for each approach.
10) Prepared a technical report, and created a photo story that documented our findings.

2 SUSTAINABILITY

The American Society of Civil Engineers defines sustainability as a set of conditions in which "all of society has the capacity and opportunity to maintain and improve its quality of life indefinitely without degrading the quantity, quality or availability of natural, economic, and social resources." In the modern world, engineers must incorporate sustainability into each of their plans, designs, concerns, and solutions; without it their designs would not meet societal demands and would be a waste of resources. The inception of this project was driven by this idea of sustainability

that stems from understanding societal values, and that responds by providing infrastructure to support social structure.

2.1 SOCIAL

The advancement of social sustainability was a significant consideration throughout the entire design process. Social sustainability is a practice that actively supports the ability of current and future generations to develop thriving and habitable communities. The aim of this project was to directly serve the needs of the Burlington DPW, while also having a positive impact on the surrounding Burlington area. The green roof design intended not only to support the community's immediate environmental health, but also to positively promote, both to locals and to visitors, the "green" Burlington image. Furthermore, the green roof was seen as a likely inspiration and precedent to surrounding businesses to also move towards green design. Beyond the green roof's perception, other societal benefits stem from potential community involvement. The public can interact with the green roof by helping to choose and maintain its plants; the community's schools can use the site as an opportunity for educational field trips; the state and other public service organizations, such as the University of Vermont, now have the capacity to research and track the performance of such a specialized design, and can use that data for the implementation of future green roofs in the community.

However, because the green roof is located on top of Burlington's drinking water supply, only qualified personnel will be given access to the roof. This fact may lead the taxpayers to refuse their support of the project, as it can be difficult to explain why their money is funding a program that is not directly accessible to the public. Furthermore, the green roof installation process would create noise, aesthetically unpleasing views, and limited parking behind the UVM Admissions building. However, the possible short-term inconveniences that a green roof would generate would be insignificant in comparison to its long-term societal benefits.

2.2 ECONOMIC

Green roofs can be economically sound, long term investments due to their ability to reduce rainfall runoff, limit energy consumption, and improve valuable city real estate. Rain runoff collected from infrastructure is treated by the City of Burlington before it enters the lake. During

high volume storms, treatment facilities become overwhelmed and must divert the collected runoff directly into the lake. A green roof can reduce this issue by collecting some of that water in the soil, decreasing the amount of water the city gets at one time. Another added benefit to green roofs is its ability to give added insulation to the building. In the summer the green roof will keep the facility cool, and in the winter it will keep the facility warm. After installation, the roof will also begin to save the facility money by reducing wear and tear, and keeping repair costs down.

The down side to a green roof is its high initial costs for installation, maintenance, and labor. In order to reach maximum efficiency, green roof plants need about two years of upkeep and maintenance to adjust to the new environment, including individual plant replacement.

2.3 ENVIRONMENTAL

Environmental considerations were some of the main focuses for our green roof project. Firstly, air quality will improve because of the specific types of plants that were used in the design. Air pollution sources are from automobiles on Main Street, and the vegetation will help to absorb some of the toxins released. Specifically, CO_2 levels locally will be used for plant growth. This will provide cleaner air for local pedestrian and bicycle traffic traveling near the water tanks. Another benefit to the local community will be the reduction of sound pollution. Vehicle traffic that currently clusters at high commuting times brings about a lot of unwanted sound. The green roof will help to break up the sound waves and provide a calmer atmosphere to homes surrounding the water tanks. Another advantage to a green roof design is the positive impact on local animal populations. Birds and other native species will have another habitat to grow because of the types of plant life chosen in the design. A major concern for growing cities is the urban heat island effect (Green Roofs, 2015). Without the natural vegetation to help cool the surrounding air, city temperatures could be as high as a few degrees warmer than in rural towns on a given day. Green roofs, like the one designed here, provide a medium for plant life to accomplish the same cooling effect, but at the same time allows cities to continue to expand.

One of the main objectives of our project was to reduce stormwater runoff generated from the impermeable roofs covering the water tanks. The green roof does this by collecting stormwater and reduces the amount that flows into the city's stormwater system. In addition, it uses the water to help support plant life installed on it. Currently, the City of Burlington has a shared sewer and

stormwater system that flows into a wastewater treatment plant that is incapable of properly treating the volume of water entering the facility. Phosphorus is a concern as Lake Champlain is prone to algae blooms (Lake Champlain, 2015). This green roof design reduces runoff flowing into Burlington's stormwater system, which will improve efficiency at the wastewater treatment plant and help to mitigate further phosphorus contamination of Lake Champlain.

2.4 RESILIENCY

Resiliency is a recent concern for many engineering projects. The ASCE's definition of resiliency is: "the capability to mitigate against significant all-hazards risks and incidents and to expeditiously recover and reconstitute critical services with minimum damage to public safety and health, the economy, and national security." (ASCE 2015) In short, the ability of a system, project, or design, to return to normal function after a disturbance. Most projects are designed with factors of safety in an attempt to prevent failure. However, as many environmental, societal, and economic conditions change over time, planning for disruption, adaptation, and recovery is essential.

For this particular project, the ideas of hazard survival, and disaster recovery are particularly important, given the city-wide reach of the drinking water in the reservoirs. Should the roof of the reservoir fail, or in the event of an extreme flood, how easily can the green roof be removed and restored? If plant life dies off, will there be an easy way to remove and replace the dead stalks? It may be possible to choose plants that will quickly re-seed open areas to replace dead plants. Response and adaptability to new situations is an important aspect of a resilient project. A modular green roof design would allow for changes in the near and far future, depending on current needs. Maintenance walkways accessing all areas of the roof can allow workers to react to problems as they arise.

Planning for and adapting to failures is worth consideration for projects with a long intended lifespan. If this green roof is only meant to last 5 years, resiliency may not be the chief concern. However, if the roof needs to last 10 years or more the design should be flexible in order to deal with changing conditions.

2.5 REGULATORY

Lake Champlain is a focal point for the City of Burlington both economically and socially. Vermont's economy relies on the usage and access to Lake Champlain, and therefore it is imperative to keep the lake healthy and functional. Recently there has been concern about the amount of phosphorus in the lake. Over the past few years, the Environmental Protection Agency (EPA) has been working with the State of Vermont to restrict the amount of phosphorus that enters the lake by proposing a Total Maximum Daily Load (TMDL) that will limit the amount of phosphorus discharged into the lake by facilities such as the Wastewater Treatment Plant (WWTP) (EPA 2015). More recently, on January 14, 2015 the United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS) chief, and Gov. Peter Shumlin announced that $16 million in federal funds have been allotted to improve Lake Champlain's water quality (Vermont.gov, 2015). There is a strong desire both locally and nationally to improve water quality and promote land sustainability. Our design has the potential to improve Lake Champlain's water quality by reducing the amount of runoff entering the sewer/stormwater system. By achieving regulatory standards, the City of Burlington can move towards a more sustainable future for its land and waterways.

Other regulatory aspects that were taken into consideration for this project include permitting (construction, stormwater, planning & zoning), American Concrete Institute Building Code Requirements for Structural Concrete (ACI 318-14), and the American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures (ASCE/SEI 7-10). The following diagram (Figure 2.1) illustrates the permitting process in the City of Burlington and is a useful guide in determining which steps to take throughout the process.

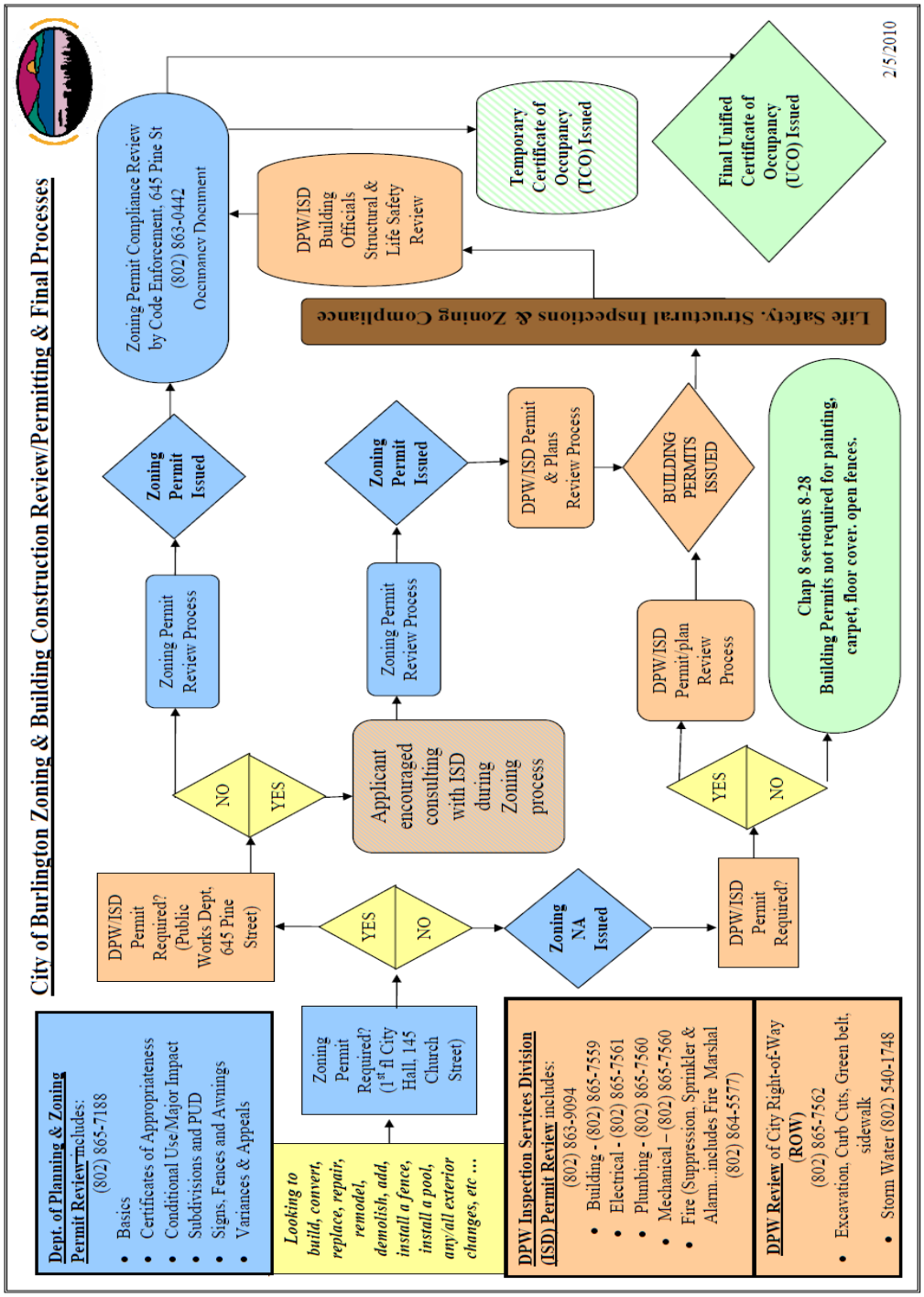


Figure 3.1 Diagram illustrating the zoning, review and permitting process for the City of Burlington (http://www.burlingtonvt.gov/DPW/Inspection-Services).

3 DATA AND BACKGROUND INFORMATION

3.1 STRUCTURAL BACKGROUND

After the construction of both reservoirs in 1981, issues with spalling and minor cracking occurred at various points along connections, beginning in 1984. The rebar in the concrete girders was not sufficient for the loads, causing unwanted deformation. In an effort to remediate this deformation, repairs were accomplished by tensioning the rebar in these girders and bracing them on the outside of the structure using steel bearing plates. An example of a steel plate that was added is shown in Figure 3.1.

Figure 4.1 Example of bearing plate repairs.

In February 1997, Knight Consulting Engineers Inc. was hired to structurally assess the two water reservoirs. Their investigation confirmed the presence of significant spalling and cracking along the edges, under the reactions of the girders. They also concluded from their observations that the structures were not constructed in accordance with the original plans. Specifically, the supports for the girders on the walls were observed to be different than the plan detail. Engineering Ventures Inc. later designed extensive repairs. This involved jacking up beams and installing new channel steel supports under the girders that were in need. Steel plates were

also used at these supports in order to mitigate cracking and spalling. This work was completed in July of 1997.

The original construction documents from 1981 were irretrievable and the documents from the repairs in both 1984 and 1997 were sparse with information. The combination of time constraints and lack of information led to many assumptions for the structural analysis. These assumptions, along with example calculations, are provided in the Analysis of Existing Conditions section of this report. Also, see Appendix C for all documents used in the analysis. These documents were provided by the community partner, Steve Roy.

3.2 BENEFITS OF GREEN ROOF INSTALLATION

Installation of a green roof can provide benefits to multiple parties including the site developer, the surrounding community, and the building occupants. Quantitative benefits include reducing the building cooling load, mitigating urban heat, reducing the stormwater runoff, and sequestering carbon in biomass. Qualitative benefits of green roofs include improving aesthetics, creating wild habitat, and providing noise reduction (GSA, 2015).

When considering the installation of a green roof, the stakeholders must consider the positive and negative aspects. From the private standpoint, the cost of installation outweighs the benefits. From a public standpoint, the benefits of the aesthetic and environmental improvements outweigh the cost (Blackhurst, 2010).

3.3 TYPES OF GREEN ROOFS

Green roofs contain multiple attributes that benefit a rooftop's space. These attributes drive varying designs and result in the existence of many types and combinations of green roofs. Green roofs are classified according to their depth and maintenance requirements and are either intensive, extensive, or a combination of the two, known as semi-intensive (Dunnett, N., and Kingsbury, N., 2008; Weiler, S., and Scholz-Barth, K., 2009). Intensive green roofs have depths of at least 6 inches, can support a wide range of vegetation, and have the capacity to retain more rainwater than other green roof types. Intensive green roofs tend to require significant maintenance as they act more like a regular garden where plants are sustained on an individual basis. Semi-intensive roofs consist of lawns and ground covering plants and are less costly, but still require regular

maintenance. Extensive green roofs have substrate depths of 0.8 inches to 6 inches, are "more ecological" in that they require less input of resources such as labor and water, and are designed to minimize maintenance. Such roofs are cheaper, and are primarily used for their environmental benefits including insulation and stormwater management (Weiler, S., and Scholz-Barth, K., 2009). Green roofs may also be hybrids of vegetation and photovoltaic cells.

Choosing which type of green roof relies directly on the load bearing capacity of the building's structure. Retrofitting a green roof onto an existing structure requires assurance that the load of the green roof is within the structure's carrying capacity (Weiler, S., and Scholz-Barth, K., 2009). Often designing modular systems for an existing structure is an appropriate choice. These types of systems are neither intensive nor extensive, but instead are comprised of interlocking units that contain growing substrate, drainage systems, and plants. The allure of this system stems from its flexibility and accessibility. Designers can choose to test the system on part of the roof before the whole roof is covered, and modules can be removed to allow access to the roof membrane if repair is needed (Weiler, S., and Scholz-Barth, K., 2009). Like all other green roof systems, the modular system enables customization. Designs vary on a case-to-case basis, and within each type of green roof classification further customization is possible. From choosing which plant species to grow, to specifying how many layers a green roof membrane may have, the designer has the capacity and the responsibility to design a green roof that suits the needs of a particular site.

4 ANALYSIS OF EXISTING CONDITIONS

4.1 STRUCTURAL ANALYSIS

Prior to performing an actual analysis, the material properties of the structural members and dimensions needed to be determined. As-built drawings were reviewed to determine dimensions of each structural member. After these parameters were found, strength of the steel and the concrete used in the construction needed to be estimated. Unistress, the company that manufactured the pre-cast concrete components, was contacted to find out information regarding reinforcing strands in the concrete, as well as, dimensions of components. An important aspect of the project was to determine the existing structural conditions of the water reservoir tanks. In order to move forward into the design phase, the existing load capacity needed to be known for what

designs would be appropriate. Initially, the plan was to determine the flexural strength of a typical double-tee beam and a typical inverted tee girder and then find the axial strength in a typical column, as well as, the cast-in-place walls. Soil properties would also need to have been found to analyze the foundations. Then, using the existing load capacity, determine how much additional load the structures can safely support. This additional load is what would have been a constraint for the green roof design.

4.2 HYDROCAD DATA ANALYSIS

Using a geographic information systems software, called ArcGIS, and the stormwater modeling program HydroCAD, we were able to create a basic stormwater simulation for the site. Stormwater runoff rates were calculated using the SCS curve number method. GIS software was used to measure the relative areas of different areas of the site. Impervious surface area was totaled, which included sidewalks, the reservoir roofs, and the nearby monitoring house roof. The gravel driveway area was calculated, and the grassy areas around the site were separately summed. Lastly, the area of the row of bushes bordering Main Street was measured. Each of these areas was entered into the HydroCAD model under a single node. After assigning each area a curve number, a composite curve number was calculated by HydroCAD (Table 4.1).

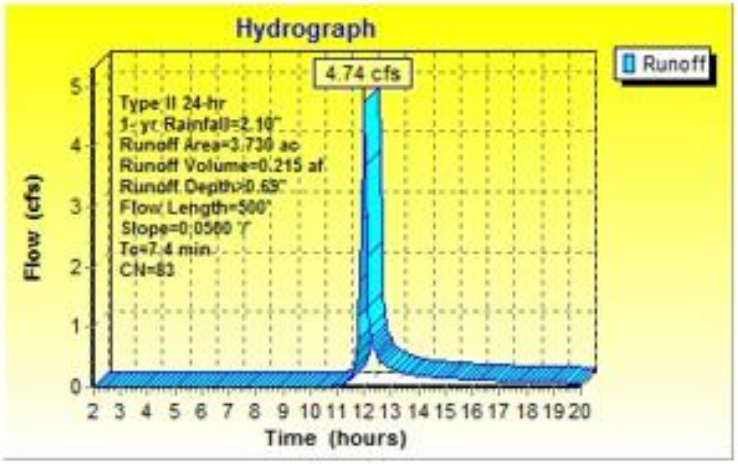
The simulation was run using 1, 5, and 10-year 24-hr storms for Burlington, Vermont. This means that the amount of rain that fell was similar to that of the largest storm in an average 1, 5, or 10 year period. Data for the storms were collected from the Rainfall Frequency Atlas of the United States, and average yearly precipitation was gathered from the U.S. Climate Data Database (U.S. Climate Data 2015). Figure 4.2 below shows the results of the preliminary analysis. The soil underlying the site is classified as Groton gravelly fine sandy loam. This information was provided to us by the Burlington Department of Public Works. Soil was not sampled directly on site, but at a nearby site. This was accounted for by slightly increasing the curve number of the grassy areas of the model.

Figure 5.1 The parameter set for the HydroCAD model.

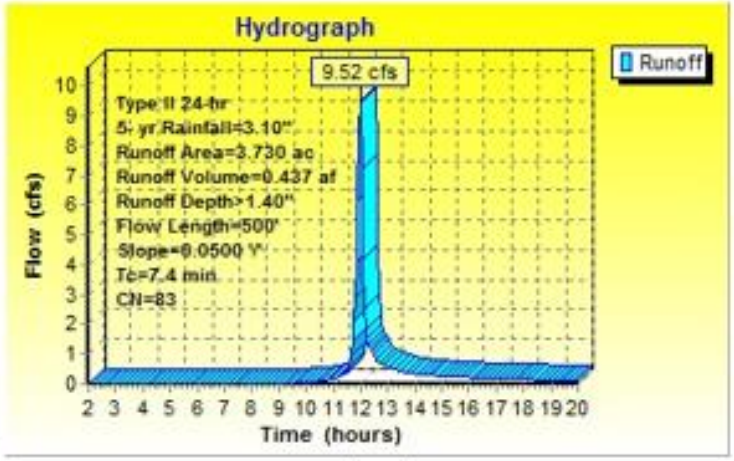
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 2.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 10- yr Rainfall=3.50"

Area (ac)	CN	Description
1.980	98	Unconnected roofs, HSG A
0.160	98	Paved parking, HSG A
1.540	61	>75% Grass cover, Good, HSG B
0.040	98	Unconnected roofs, HSG A
0.010	62	Row crops, C&T, Good, HSG A
3.730	83	Weighted Average
1.550		41.55% Pervious Area
2.180		58.45% Impervious Area
2.020		92.66% Unconnected

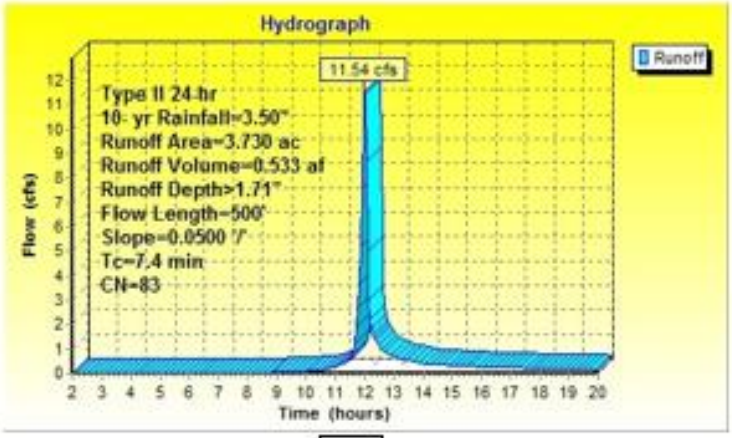
Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.4	500	0.0500	1.12		**Lag/CN Method,**



A



B



C

Event	Runoff (cfs)	Volume (acre-feet)	Depth (inches)
1- yr	4.74	0.215	0.69
5- yr	9.52	0.437	1.40
10- yr	**11.54**	**0.533**	**1.71**

D

Figure 4.1 Hydrograph of a A) 1 year 24hr storm, B) 5 year 24hr storm, C) 10 year 24hr storm, and D) a table of runoff, in ft^3 per second, Total Volume, in acre-feet, and depth in inches.

5 DESIGN ALTERNATIVES

5.1 DO NOTHING

The roofing membrane of both reservoirs will need to be replaced in the near future. The current material has suffered "wear and tear" and will soon be unable to shelter the concrete beneath. Simply replacing the 30+-year-old membrane with another of the same type will have negligible effect on stormwater runoff. This is the least expensive option out of all possibilities in terms of up front construction costs.

5.2 EXTENSIVE GREEN ROOF

Our extensive roof design will be seven separate layers including a vegetative layer, growing medium, filter fabric, drainage mat, insulation, root barrier, and roof membrane.

The vegetative layer will be comprised of low-lying sedums that do well in the Vermont environment. The plants seen in table 5.1 were chosen based on their success as a part of the green roof on the Aiken Center. Sedum stem cuttings will be inserted into the media as a cheap method to establish a uniform ground cover. The growing medium will be 4 inches deep, and will be modeled after the Aiken Green roof to ensure plant longevity. This soil would be comprised of expanded shale, biosolids compost, perlite and fines. Shale will be used in the soil to ensure good soil drainage, as well as compost nutrients to the plants.

Figure 6.1 Extensive Roof Plant List

Sedum album
Sedum sexangular
Sedum Weihenstephaner Gold
Sedum kamschaticum
Allium schoenoprasum Allium sp./Chive
Sedum spurium, Fuldaglut
Sedum spurium, John Creech
Opuntia humifusa

A filter fabric will be installed underneath the growing media made up of non-woven non-biodegradable polypropylene geotextile that is tear resistant and has high water permeability. This will keep the soil in place while letting the water pass freely to the drainage layer. A key part to this fabric is not allowing the water to pool in the growing medium as this can lead to root rot.

Below the filter fabric will be a crush resistant interwoven drainage mat that will be installed to maintain good flow of water throughout the system and have a compressible strength of at least 20,000 psf.

Underneath the drainage mat an insulation layer will be installed to prevent the roots from freezing in the winter, and from getting too hot in the summer. The recommended insulation is extruded polystyrene because it will not absorb water.

Below the insulation layer a root barrier will be installed. This ensures that the waterproof membrane is protected from any damage. It is recommended that this layer be high-density polyethylene to ensure maximum protection.

One of the most important layers will be the waterproof membrane that will separate the water reservoir structure from the green roof. The current membrane will be replaced in the coming months, so in order to allow the potential of a green roof installation we recommend that Burlington DPW keep a potential vegetative layer in mind. This will include considering a membrane layer that is UV resistant and installation of leak detection equipment.

The extensive green roof design is semi versatile and can be used in both partial and full roof coverings. For our design we planned on using the 50% covering in order to use the roof walls to secure the design, but minimize the weight on the roof. The upside to this method is the extensive roof provides the most soil retention. The downside is the lack of mobility, and the time until plant maturation.

In order to ensure the roof's health, a two-year maintenance period by trained professionals is recommended. This is generally done by the installation company and will include maintaining a clear drain, plant clipping, and debris removal.

5.3 MODULAR/TRAY SYSTEM FOR GREEN ROOFS

Our modular design involved placement of green roof trays along the length of the inverted-T girders. They would cover the area 7 ft. off center on either side of the girders on both the Northern and Southern reservoir. This method would cover approximately 20% of the total roof area and minimize additional load in the center of the double-T beams.

The layers and vegetation of this method would be similar to the other extensive green roof designs. However, these trays would be easier to install and move once placed on the roof. In addition, green roof trays are very similar to potted plants, in that the vegetation is already fully matured and would not need much maintenance after installation. This allows for future changes to the placement of each tray, if a better solution were to be found.

This system would also provide an incentive for the City of Burlington by reducing the amount of impermeable area. This would, in the long run, reduce the cost of a stormwater utility tax. Finally, this method would allow the City of Burlington to invest the money in a green roof system. So, when the reservoirs need to be replaced, the green roof trays can be saved, or moved to different roofs if necessary.

5.4 CONTINGENCY

In case it was found that the reservoirs are not capable of handling the increased load that a green roof would impose, a retention pond, rain garden and/or check dams were all considered as an alternative design. The purpose of retention ponds, rain gardens and check dams would be to slow the flow of stormwater runoff into the sewer/stormwater system. The project site has limited ground space, so a concern would be not having enough space to implement a retention pond of adequate size. Soil at the site is believed to be Groton gravelly fine sandy loam, which as previously described is fairly impermeable.

Similar to a retention pond but smaller scale, a rain garden could be used to help slow the flow of runoff from the site. A rain garden could be placed in one of the multiple runoff flow paths or around each of the catch basins. The third option would be to place check dams along the pathway on the east side of the north reservoir. Approximately one third of the water from the south reservoir and a quarter of the water from the north reservoir roofs currently flows down an

asphalt swale on the east side of the north reservoir. See Figure 5.1 below. Stone check dams could be placed along this asphalt swale to help slow the flow of runoff during a storm.

All three of these options avoid increasing the load on the structure while still slowing the flow of runoff into the city's sewer/wastewater system. The use of both a rain garden and check dams was considered as well as other combinations of these design features.

Figure 5.1: Flow diagram of storm water runoff from site roof.

5.5 REPLACE THE ENTIRE STRUCTURE

Given the current structure's state of disrepair and its inability to hold an entire green roof, a complete rebuild of the structure may be warranted. Eventually the structure will have to be replaced, unless an alternative is found. Total reconstruction will prevent many possible problems down the road, such as structure collapse. Replacing the structure entirely will allow for a stronger roof design, and therefore a more expansive green roof system. This is, however, extremely

expensive and time consuming. A new building would have to be designed, approved, and built before the old roof wears out, or else a needless replacement of the current roof would be required. Construction of a new reservoir would be unpleasant for the houses adjacent to the property, due the noise, pollution, and traffic delays it would cause. This solution is the most expensive, costing several million dollars.

6 ANALYSIS AND DESIGN

6.1 STRUCTURAL ANALYSIS AND DESIGN

The main goal of the structural analysis was to determine if the water reservoirs have the structural capacity to support the additional load of a green roof. Typically a structure is analyzed from the top down, therefore the double tee girders were analyzed first. Calculations were performed to estimate the nominal flexural strength of the double tees. The mathematical programming software, MATLAB, was used to compute the nominal flexural strength. However, the equations used for the calculations were taken from AASHTO LRFD Bridge Design Specifications 5.7.3.1- Stress in Prestressing Steel at Nominal Flexural Resistance and section 5.7.3.2- Flexural Resistance. The estimated factored nominal flexural strength of a typical prestressed double tee girder was found to be 410 kips•ft.

ASCE 7-10 was used to determine the factored load combinations for the structures. The self-weight of a double tee beam was estimated to be 79.2 psf but in order to be conservative, account for contingency, and to account for the weight of the waterproofing membrane, a self-weight of 82 psf was used in the factored load. The controlling factored load on the girder under its own weight was 192 psf with a 40 psf live load and 33.3 psf snow load. Converting 192 psf into a distributed load along the double tee girder, it was multiplied by the width of the girder, 10 ft, and converted from pounds to kips to get 1.92 kips/ft. A range of moment was then solved for using the shortest and longest double tee span length, 347 kips•ft – 403 kips•ft. Now the factor of safety (F.S.) of the double tees was found by dividing the factored nominal flexural strength, 410 kips•ft, by the actual moment due to the self-weight of the longest span, 403 kips•ft, which was a F.S. of 1.02. Similarly, 410 kips•ft divided by 347 kips•ft gave a F.S. of 1.18 for the shortest span double tee beams. These are extremely low factors of safety which means the beams are

experiencing a load that is very close to its design capacity. This indicates that additional load on the beams could lead to failure. Therefore, it was decided that constructing a green roof, of any load, would be unsafe for these existing structures.

It is important to note that there are a lot of unknowns for structures of this age with limited information about original construction. As well as the modifications that have been made over the years. Also, these structures are not accessible for internal observation because they house clean drinking water which cannot risk contamination. Without the ability to visually inspect the condition of structural members inside the reservoirs and based solely on the analysis results, it was very important to consider a large amount of contingency and make a conservative conclusion not to place green roofs on these reservoirs.

If the double tee beams had been able to sustain additional load, the next step would have been to analyze the inverted tee girders, then the columns and walls, following the load path to the foundations. It was unnecessary to complete these calculations because if the double tee beams fail under additional load then it can be concluded that a green roof is not a safe option for these structures. The dead load of each structure was estimated as a preliminary analysis calculation that would have been used in future calculations had the double tee beams been able to support additional load.

Although it was decided not to place green roofs on the water reservoirs, three green roof options were designed with the intention of providing the DPW with designs that could be used on other city owned buildings. Another option that was considered was to retrofit the existing structures so that they would be structurally capable of handling green roofs. This alternative was not pursued because it would require a thorough analysis of the current condition of the structural components, which was not possible during the duration of this project.

Note: Reference Appendix D for all structural analysis calculations.

6.2 GREEN ROOF ANALYSIS AND DESIGN

<u>Static Components</u>

I. Waterproofing
II. Protection Board
III. Insulation
IV. Root Barrier / Filter Fabrics / Drains
V. Aeration Materials / Moisture Retention Materials

Dynamic Components

VI. Soil/Soil Mixtures / Growing Medium

VII. Soil Additives

VIII. Plants

I. Waterproof Membrane: Single-Ply Thermosetting EPDM

The waterproof membrane protects the slab below and keeps unwanted moisture from damaging the structure. The waterproof membrane lies below all of the green roof components, and because of this can be difficult to access and repair. The membrane selection, installation and protection are paramount to the resilience of the green roof design, and its failure can lead to failure of the entire structure.

The waterproof membrane suggested is a single-ply thermosetting EPDM (ethylene, propylene, diene, terpolymer) membrane, an extremely durable synthetic rubber roofing material, widely used for low-slope roofs. An EPDM membrane is suggested because it is considered the most sustainable waterproof product when considering toxicity, membrane life cycle, and membrane recyclability, and averages a serviceability of 10-15 years. The membrane comes in wide rolls ranging from 50 to 100 feet, and hence can cover large areas with minimal seams, which lessens the potential for leaks. These membranes are vulcanized or cured at the factory, and only need to be rolled out, joined at the seams, and adhered with adhesives to the roof deck; because of this they are easy to install and require less labor than other roofing systems. Further, they are considered a good system for green roofs because of their resistance to root penetration and hence an additional root barrier may not be necessary.

II. Protection Board: Insulation Panels or Temporary Protection Layer

Protection board may be any material placed on top of the waterproofing membrane that protects the membrane below. It is a very important component of the green roof structure, because once the waterproofing membrane is installed it is susceptible to damage from construction activities. As discussed earlier, if the membrane is damaged and allows water to reach the slab below, the entire structure could be compromised.

Because of load and cost concerns, as well as project size considerations, two different options for protection board are suggested. In the interest of cost savings, the insulation board can adopt a dual purpose and act as both insulation and protection for the membrane below. However

any damage experienced by the insulation as a result of its dual role could limit its long-term performance, further, under heavy construction, insulation panels will do little to protect the membrane below. The second option is to install a temporary protection layer on top of the membrane, such a felt or proprietary particle board, but this protection is only temporary and would add unnecessary costs to the design.

III. Insulation: IRMA Extruded Polystyrene Boards (xPs)

Since insulating the structure below the green roof is not of primary concern, the primary purpose of insulation in the scope of this project is to minimize the freezing, thawing, and refreezing of the plants and rigid planter walls, especially because Vermont can experience many freeze-thaw cycles every year. Insulation underneath the vegetation layer can also help protect the plant's root systems, and therefore can maximize plant health and efficiency of water absorption. Because of this, the preferred location of the insulation is above the waterproofing membrane, and is referred to as a protected or inverted roofing membrane assembly (IRMA). When the insulation is placed above the waterproofing membrane, it reduces the chance of condensation beneath. Further, IRMA installation techniques are easier and less costly, and can also act to protect the waterproofing membrane below.

Considerations for insulation include the insulation's material composition, compressive strength, resistance to water absorption, R-value, and ability to promote or guide the flow of water. The insulation suggested is the planar, extruded polystyrene boards (xPs) which provide a very dense, hydrophobic insulation that resists compression and prevents moisture uptake. This type of insulation is an extruded foam product, and can be produced in 2x8-foot or 4x8-foot sizes, with thicknesses of 1 to 5 inches. The suggested thickness of the xPs to be used should be between 2-3 inches, which should adequately insulate the plant's root systems. This type of insulation is lightweight, and therefore, minimizes load on the structure below. It is easy to handle and can be field-cut, providing simple installation, and lower installation costs. However because this product is petroleum-based, it can fluctuate with world-oil costs, and may constitute significant costs as a result (Weiler, S., and Scholz-Barth, K., 2009).

Insulation, particularly if installed as a tongue-and-groove assembly, can cause water to pond. In order to avoid this condition, two different options are presented. The first, and highly suggested, is to require chamfered insulation panels that create drainage channels which facilitate

the flow of excess water. The second option would be to have both chamfered insulation panels along with an additional thin drainage mat or panel which would help to prevent standing water and waterlogged insulation, especially on low-sloped decks.

IV. Root Barrier/ Filter Fabrics / Drains: Geo-textile Mat and Filter Fabric

Drainage is a key part to this system because water pooling will damage the roof membrane and cause rot in the plant roots. To ensure consistent flow of water off of the roof we chose a geo-textile mat paired with a filter fabric on top, and a soft fabric below. The geotextile was chosen over granular rock fill because it is lighter, easier to install, and are strong enough to sit above the roof. This geotextile is made of plastic and should be designed with multiple small cups to retain water for future plant use. The filter fabric on top of the geotextile is in place to prevent fine medium from getting loose and plugging the pores of the drainage layer and the drainage outlets. This layer can also act as a root barrier, therefore we recommend the material to be made up of non-woven polypropylene. This does not need to be heat welded together because we are not considering an intensive roof with aggressive roots. We do not recommend the geotextile on top of a soft fabric because the drainage will sit on top of the insulation. For each scenario, it is recommended that the perimeter of the roof be detailed with perforated edges that will contain the fine particulate as well as the green roof media as well as drain to designated locations on site.

V. Aeration Materials / Moisture Retention Materials

These materials have been deemed unnecessary. Aeration materials are generally required for intensive roofs, which is not a part of our design. Moisture retention materials were left out of the design as the Vermont climate is wet enough to allow for a typical drainage system.

VI. Soil / Soil Mixture / Growing Medium

The green roof soil composition was determined with parameters of good drainage, bio-solids to promote plant health, and aeration to facilitate good root growth. Green roofs work best when they are made up of 25% organic material and 75% non-organic material as organic material can become saturated and heavy creating a strain on the roof. Our proposed growing medium will be made up of 65% lightweight shale, 10% perlite, 10% fines, and 15% bio-solid compost. Shale was chosen because it is lightweight, creates large amounts of pore space, and absorbs water due to its porous nature. Perlite will be used as a soil additive for its moisture wicking, aeration, and

drainage qualities. The bio-solid mix will be made up of compost material to give the plants the nutrients they require, but not encourage vigorous growth that will be unsustainable. A small portion of fines will be added to increase moisture retention, but not enough to clog the drainage fabric. For the ideal scenario we plan to use 6 inches of soil, and 4 inches of soil for the economical extensive system and modular systems.

VII. Soil Additives

Biochar is a fine-grained, highly porous charcoal substance that has been used as a soil amendment for thousands of years. This would only make up 7% of the soil medium, but has water retention, nutrient removal, and increased plant growth capabilities. Gary Hawley used Biochar as a soil amendment, and saw a 40% increase in soil water retention when compared to the standard green roof so we feel we may see some of the same results. The downside to Biochar is that it is more expensive so it will be used in our ideal design. The results of Hawley's experiment can be seen in appendix F.

VIII. Plants

The recommended plants were chosen to not require phosphorus fertilizer, maximum water retention by leaves and stems, plants that were least susceptible to drought, wind, have gray or silver foliage to reduce water loss, and would have a shallow dense root system. Sedums fill all of these parameters, and will provide for a long lasting sustainable roof. The plant list as seen in design alternatives was chosen based off of plants already in use the Aiken green roof, so that it is proven they will be successful in this Vermont climate.

6.3 DESIGN CASES

Three green roof design cases were formed from components I-VIII discussed above. While minute differences exist between each, all cases are appropriate for the project site and were designed in direct response to the project's goals. Cases 1-3 are presented below.

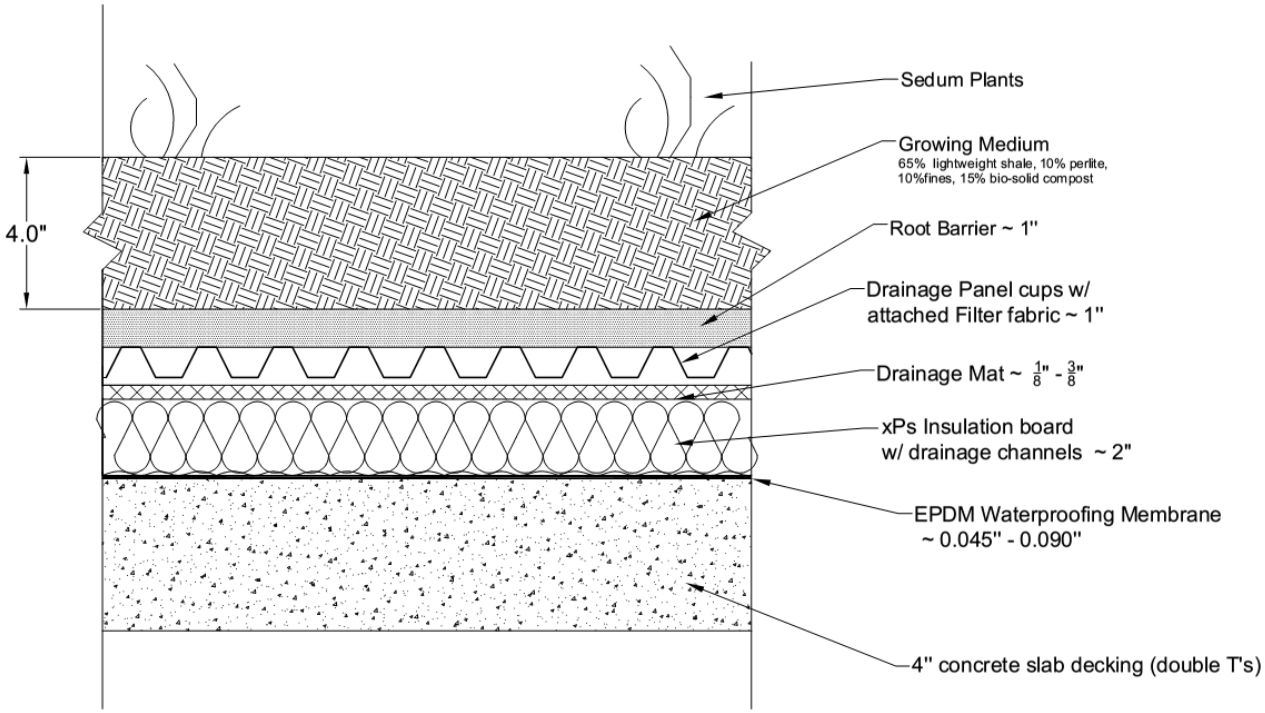
Case 1: Low-Cost Extensive Green Roof

This case was designed to minimize cost of green roof installation and maintenance. Table 6.1 compiles the roof components, thicknesses, and loads. Figure 6.1 found in Appendix E shows a typical cross-section of the design. In this design, both cost and load are minimized, using a shallow soil depth of 4 inches. Because of this thinner soil layer, less insulation for the soil is needed, and only requires a 2 inch insulation board.

Figure 7.1: Low Cost / Low Load Extensive Green Roof

Case 1: Low-Cost / Low-Load Extensive		
Roof Components	Thickness	Load (lb/ft^3)
EPDM Waterproofing Membrane	0.045" - 0.090"	0.0015
xPs Insulation Board w/ Drainage Channels	2"	0.0833
Drainage Mat	1/8 " - 3/8 "	0.125
Drainage Panel cups w/ Attached Filter Fabric	1"	0.0625
Root Barrier	1"	0.0292
Growing Medium	4"	21.79
Sedum Plants.	N/A	N/A

Total Load: 26.13 lb/ft^2
Volume of water retention capacity: 5749.92 ft^3



CASE 1: GREEN ROOF DESIGN	FIGURE 6.1	APPENDIX E
CE175 SENIOR DESIGN PROJECT	SEE TABLE 6.1	APRIL 2015

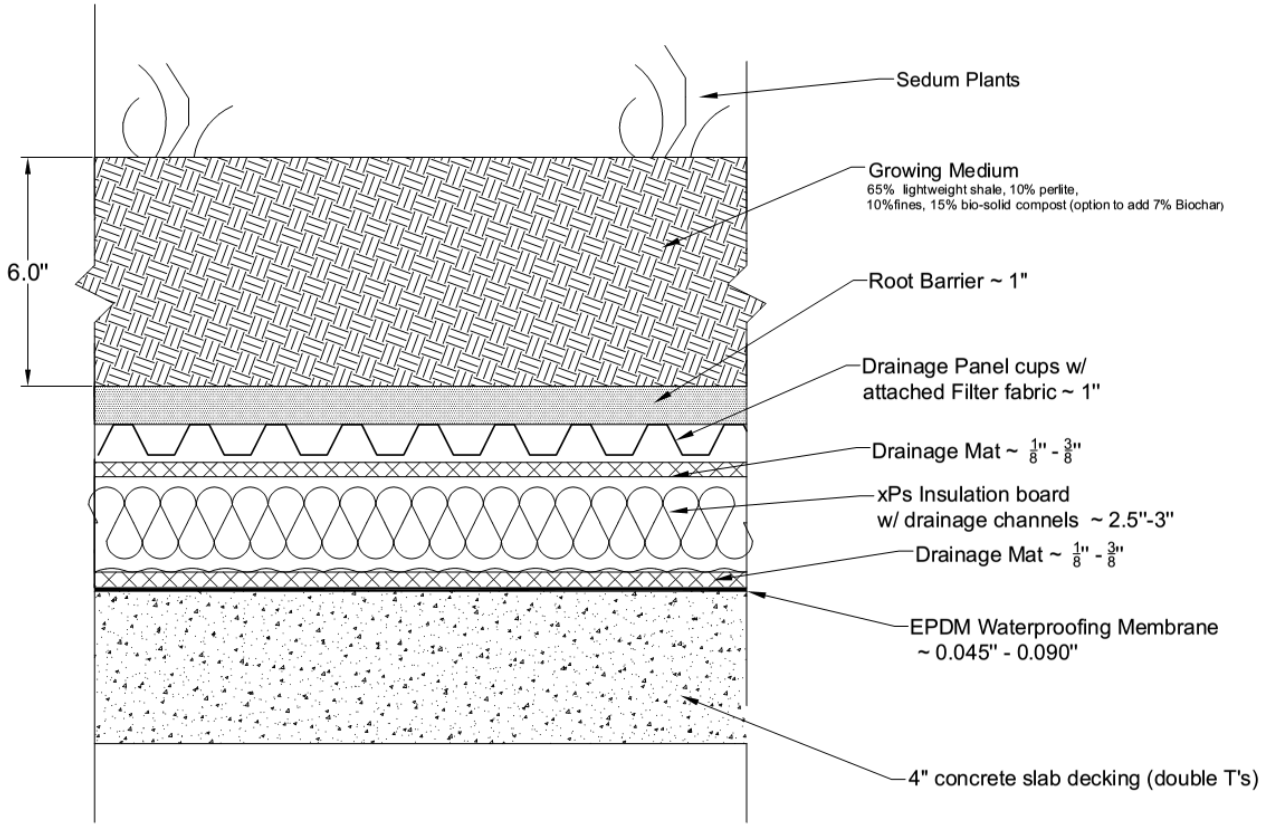
Case 2: Ideal Extensive Green Roof

This design increases soil volume to 6 inches in order to increase the roof's water retention capacity. Table 6.2 compiles the roof components, thicknesses, and loads. Figure 6.2 found in Appendix E shows a typical cross-section of the design. However, with this increased soil depth, the load on the structure below also increases. It also has the addition of another drainage mat below the insulation layer, which has the benefit of preventing the pooling of water beneath the insulation layer, as well as facilitating the movement and drainage of water off of the roof. Further, this design provides the option of including a soil additive, Biochar, which would constitute 7% of the total soil volume, and has properties of increasing the soil's water retention capabilities.

Table 6.2: Ideal Extensive Green Roof

Case 2: Ideal Extensive		
Roof Components	Thickness	Load (lb/ft^3)
EPDM Waterproofing Membrane	0.045" - 0.090"	0.0015
Drainage Mat	1/8 " - 3/8 "	0.125
xPs Insulation Board w/ Drainage Channels	2.5"- 3"	0.125
Drainage Mat	1/8 " - 3/8 "	0.125
Drainage Panel cups w/ Attached Filter Fabric	1"	0.0625
Root Barrier	1"	0.0292
Growing Medium	6"	32.5
Sedum Plants	N/A	N/A

Total Load: 39.208 lb/ft^2
Volume of water retention capacity: 8624.88 ft^3



CASE 2: GREEN ROOF DESIGN	FIGURE 6.2	APPENDIX E
CE175 SENIOR DESIGN PROJECT	SEE TABLE 6.2	APRIL 2015

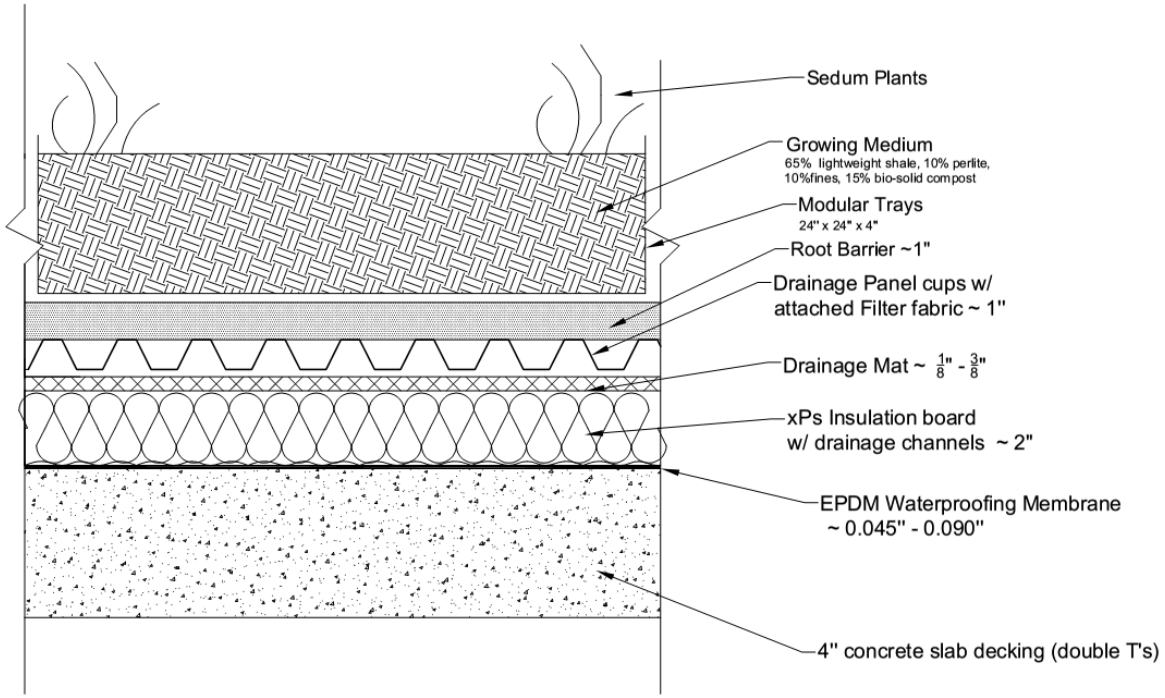
Case 3: Modular System Green Roof

This design is comparable to design case 1 in terms of thickness and load, but instead has the benefit of providing more accessibility to the structure below. Further it can provide more immediate benefits because plants can be grown in their modular trays off-site and installed at their maturation. Table 6.3 compiles the roof components, thicknesses, and loads. Figure 6.3 found in Appendix E shows a typical cross-section of the design.

Table 6.3: Modular System Green Roof

Case 3: Modular System		
Roof Components	Thickness	Load (lb/ft^3)
EPDM Waterproofing Membrane	0.045" - 0.090"	0.0015
xPs Insulation Board w/ Drainage Channels	2"	0.0833
Drainage Mat	1/8 " - 3/8 "	0.125
Drainage Panel cups w/ Attached Filter Fabric	1"	0.0625
Root Barrier	1"	0.0292
Modular Planting Trays	24" x 24" x 4"	0.9
Growing Medium	4"	21.79
Sedum Plants	N/A	N/A

Total Load: 27.03 lb/ft^2
Volume of water retention capacity: 5749.92 ft^3



CASE 3: GREEN ROOF DESIGN	FIGURE 6.3	APPENDIX E
CE175 SENIOR DESIGN PROJECT	SEE TABLE 6.3	APRIL 2015

7 PERMITTING

The following permits were determined to be applicable to our project:

- General permit 3-9015
- Burlington Zoning and Construction permits

All relevant permit forms can be found in Appendix G. For Burlington zoning and construction permits follow the flow chart provided in Figure 2.1 to meet necessary permitting standards.

We do not require an Act 250 because Burlington, VT is considered a "10-acre town". This means that because our project will disturb less than 10 acres of land, the state permit is not needed and the local Burlington permitting process can be followed.

We do not require a Construction General Permit 3-9020 for stormwater runoff during construction because our project was determined to be "low risk". The form from the appendix of the Construction General Permit 3-9020 is provided in our Appendix G.

It is advised to submit this project to the local Vermont ANR permit specialist. The permit specialist will determine the necessary permitting required to complete the project. The closest permit specialist's contact information is provided below:

Jeff McMahon | Permit Specialist
111 West Street
Essex, VT 05452
Telephone: (802) 477-2241
Fax: (802) 879-3871
Email: jeff.mcmahon@state.vt.us

8. COST ESTIMATES

Cost estimates were generated for the three different green roof design cases. Generally, green roof installation costs vary by type and are measured by square foot. A multicourse extensive installation is the cheaper option and costs between $10.30 to $12.50 per square foot. A semi-intensive installation is the more expensive option, and costs between $16.20 to $19.70 per square foot. A modular/tray system using 4" sedum plots costs between $16.00 to $18.00 per square foot. Annual maintenance for the green roof can be expected to cost $0.21 to $0.31 per square foot. The cost variation is due to many factors including location, site access availability, growth medium, plant types, and soil substrate used (EPA, 2015). Specific green roof component costs will depend on which manufacturers supply the components.

Square footage of roofs used to estimate costs= 1.98 acres = 86248.8 ft^2

8.1 Future Costs

Maintenance costs are the foreseeable future costs for the green roofs. This particular maintenance cost applies to all design cases because the plants are all the same. This cost covers watering, replacement plants, and general upkeep. Generally the first few years after installation require the most maintenance while the plants get established and thus have a higher cost (usually around $0.50 per ft^2). Over the life of the green roof the average annual cost is lower ($0.21 to $0.31 per ft^2) than the initial maintenance cost. The present worth was calculated using $0.31 per ft^2 because it is the most appropriate for the plants used in the design cases.

8.2 Present Worth Analysis (annual payments):

$$PV = A \times \frac{(1+i)^n - 1}{i(1+i)^n}$$

A = $0.31/$ft^2$ * 86248.8 ft^2 = $26,737.13

I = 3% = 0.03

N = 30 years

PV = $524,059.55

Capital Costs

Initial capital costs were calculated for each recommended design case using the average per square footage prices. These prices for extensive roofs were determined by Peck and Kuhn in Design Guidelines for Green Roofs, and the modular tray prices were determined by NYC Parks Green Roof Laboratory.

Design Case 1- Low Cost Extensive Green Roof

$10.30 to $12.50 per square foot (Avg= $11.40 per square foot)

Average cost= $11.40/ft2 *86248.8 sqft = $983,236.32

Total present value = $983,236.32 + $524,059.55 = $1,507,295.87

Design Case 2- High Cost Extensive Green Roof

$16.20 to $19.70 per square foot (Avg= $17.95 per sq ft)

Average cost= $17.95/ft2 * 86248.8 sqft = $1,548,165.96

Total present value = $1,548,165.96 + $524,059.55 = $2,072,225.51

Design Case 3- Modular/Tray System

$16.00 to $18.00 per square foot (Avg= $17.00 per ft2)

Average cost= $17.00/ft2 * 86248.8 sqft = $1,466,229.6

Total present value = $1,466,229.6 + $524,059.55 = $1,990,289.15

Design case two has the highest cost with case three slightly less expensive, but case one is approximately half a million dollars cheaper which is significant. Since all three design cases are independent of a location, the location does not have an effect on these price differences. The

growing medium and other differences in the design components are what cause the cost differences. When an appropriate site is chosen to install a green roof in the City of Burlington, the location and site accessibility will alter these costs, which should be kept in mind.

9. CONCLUSIONS

This section includes the following:

- Brief overview of the project and motivation
- Design alternatives considered
- Preferred alternatives (preferably ranked), cost implications, advantages and disadvantages, and how they address the stated project objectives
- How and to what extent sustainability could be achieved

The water reservoir roofs on Main Street consist of 1.98 acres of impervious surface that is contributing to the overburdening on the water treatment facility on Main Street. A green roof is a living tool that could be used to lessen the burden of high rainfall events on the current Burlington water treatment system. Although in its current state the Main street structure cannot hold an addition load, if it were to be structurally enhanced, we recommend using this green roof technology, or elsewhere in the city.

Our recommendation is the low cost, low load 4" extensive green roof. This will have great water retention properties, but will require a full coverage of the roof. This would have a present worth cost of $1.5 million. Our second recommendation is Case 3, the modular green roof system, because of its quick and easy installation and maintenance, water retention potential and its minimal load on the roof. If there were to be structural improvements to the reservoirs, this method could easily be adapted to a partial roof cover. This would have a higher cost due to the pre made trays, with the present worth coming to $1.99 million. Our final recommendation would be Case 2, the six inch extensive roof. This would be a great method to consider for a structure that could accommodate a full coverage roof, with the ability to hold more load. This

method has the largest water retention properties, but will add the most load to the structure. This roof is our most expensive option since it has more soil, and would have a present worth of about $2 million.

These models have the ability to help limit the impact Burlington has on the lake, and give more control during storms to the water treatment facilities. This type of roof after 2 years requires minimal maintenance while continuously providing the same amount of storm water retention. Despite the large upfront cost, this project has the ability to reduce wear and tear on the roof membrane, and reduce any future impervious surface taxes. Environmentally this green roof has the ability to reduce air pollution, and reduce the impact of nutrient rich water runoff that eventually leads to algae blooms in Lake Champlain.

ACKNOWLEDGMENTS

Special thanks and appreciation to the following for your help and guidance throughout the process: Dr. Dewoolkar, Dr. Pearce, Dr. Hernandez, Dr. Bomblies, Gary Hawley and Steve Roy, P.E.

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APPENDICES

APPENDIX A- Meeting Minutes

APPENDIX B- Billable and Administrative Hours

APPENDIX C - Available Data and Background Information

APPENDIX D- Structural Analysis Calculations

APPENDIX E- Design Cases and Calculations

APPENDIX F- Aiken Roof Data

APPENDIX G- Permits