Center Storage

163 Mountain Road

Rt 124

Energy Assessment

Building Description and Energy Consumption

The building at 163 Mountain Road was originally constructed pre 1960 as a fire station for Jaffrey Center. It is a concrete block building built on, according to the Turner Report, a poured frost wall. It is an overall 30'x72' for approximately 2160 sq ft floor area. A gable roof covers 30'x60' feet and the back 12' section has a shed roof sloping to the back. The roof is vented with gable vents.

Oil deliveries for heating have averaged 1072 gallons over the past two years, which is approximately 400 gallons more than the two years before. There is a possibility that deliveries to a wastewater pump station close by on Rt 124 were included on the delivery to 163 Mountain Road. However this has not been confirmed. It would, of course, impact the estimates for energy reduction in the recommendations.

Electric consumption was 760 KWH for a possible total building site energy use over 152MMBtu's and index of 70.6K/Btu per sq ft /year. Total energy cost from June '09 through July '10 was

The building is used for storing various vehicles, apparatus and some office equipment.
The prudent question to ask is whether this equipment needs heated storage.
The recommendation would be to assess each piece of equipment and determine exactly if it needs heated storage and if so, what would be the minimum accepted temperature.

Assuming that the equipment must be kept above freezing, this assessment is offered.

Envelope Assessment

The greatest heat loss load is the uninsulated walls. There is, according to the Turner Report, limited insulation above the ceiling. Vehicles obstructed access to the attic hatch for this assessment to confirm quantity or quality. Infra red scanning before and during the blower door test indicate insulation between the joists and thermal bridging from framing.

IR also indicates air leakage from above the top plates and soffits.

Air Exchange

Blower Door Testing result for the whole building was 4239CFM50 and 10ACH50.
Air leakage occurs at doors, window openings, and at the top of the CMU walls.

Energy Load Assessment

Convective Losses: Air infiltration 15%

Conductive Losses:
Uninsulated CMU walls 76%
Ceiling (Est) 6%
Overhead Doors 2%
Exterior Doors 1%
Windows <0%

As is often the case, the components of the envelope that represent minimal conductive losses contribute the greatest to air leakage and convective losses. Significant contributors to air leakage are in bold above.

Heating Equipment
The building is heated by a Thermopride furnace Model #OL 16 125RB. Input 156,250 Btu's/hr. A single duct runs along the back wall of the garage bays. The thermostat is set to 60º year round, though actual temperature varies throughout the building based on convective losses and limited distribution of heated air.

Electrical Loads
Envelope loads impact electrical use as well as fuel consumption. Electricity needed for the blower fan on the furnace and very limited lighting loads.

Turner Report Recommendations Summary
The Turner Report recommendations included repairing any rotten trim and painting T-111 siding; re-pointing and caulking certain CMU areas; lowering perimeter grade to expose lower CMU course and weep joints and install a stone drip edge.

More direct energy related recommendations include; Replacing the steel door on the west; replacing roof shingles in the near term, reflashing, and adding eave vents; increasing attic insulation and consider adding rigid foam to the exterior.

SEEDS' Recommendations

1. Weather-strip back steel door and overhead doors.
Estimated cost: $450
2. Remove both windows in back storage area; frame in and insulate with 2" rigid foam and air seal in place and install exterior finish surface.
Estimated cost: $200

3. Remove all insulation above ceiling. Air seal all ceiling penetrations. Metal flash and fire stop around chimney. Spray closed cell foam on top plates and create a dam between propa vents and insulation layers. Blow in an even later of 18" cellulose.
Estimated cost: $5,940

Estimated savings from 1-3: 225 gallons; 2800 lbs carbon and an estimated $590/yr

Phase II Recommendations

The goal of Phase II upgrade is to create a super insulated and very air tight structure suitable for storage, in keeping with Turner Report's suggestion. More design details would be necessary but a brief description is below. Cost estimates are very rough and dependant on siding selection. Costs include methods to manage air, moisture and heat transfer based on building science principles and include several recommendations from the Turner Report.

In keeping with The Turner Report, clear away excess vegetation and excavate perimeter of the building. Further, excavate down frost wall and install Tuff N'Dri and 2" Warm N Dri insulation board. Install a drain pipe wrapped in cloth and fill trench with washed stone.
Once water can be effectively drained away from the building, secure two layers of 2" XPS to the CMU and attach selected siding over an air space.

Estimated cost $19,500

Equipment Recommendations
Design Heat Load following a super insulated foundation, wall and ceiling will be under 19,000Btu' sq ft. Heating equipment to maintain the building at 50 degrees will be minimal and should be re visited following the retrofit.

Department of Public Works

Knight Street
Energy Assessment

Building Description and Energy Consumption

There are a number of buildings within Jaffrey's DPW complex on Knight Street. The main garage and administration building is the topic of this report.

The 40' x 108' garage and 32' office wing was built in 1964 on a 40'x100' monolithic, uninsulated slab. The walls are 8" masonry block. The roof a wooden frame structure with asphalt shingles. The building runs east-west. A small boiler room was added on the north wall in 1967 following a fire and the structure was extended to the west in 1980 to the end of the building. In 1986, a 28' x 22' stick framed (presumably 2x4) structure was added behind the 1980 addition. The subsequent roof line creates an L shaped gable structure, extending onto a low pitched shed roof on the north. Snow melts quickly and significant ice dams occur, with long icicles over the overhead doors.

The four year average heating oil use is 5,329 gallons. The '09-'10 season used only 4,513 gallons. Some of this reduction may have been the result of added ceiling insulation but it is not believed to account for all, or even most of it. For the sake of this assessment, the energy used from July '09 through June '10 will be used: Oil – 4513 gallons for a cost of $9,911; Electricity – 38,280kWh for a cost of $6,005. Total site energy Btu's were 762.4MMBtu's or 155.6KBtu's per sq ft and $15,911.

Air Exchange

A blower door test was not conducted due to health and safety concerns. The results would have been of limited value to the assessment of this building anyway.

Envelope Assessment

Of the 4,760 sq ft of wall surface area, only 752 sq ft, or 15% of the wall area, is insulated to any degree. Uninsulated concrete blocks, regardless of thickness, have an R value of 1. The office which is insulated is constructed presumably with 2x4's with 3.5" fiberglass batts for an effective R7 wall assembly. The admin wing has a vented roof. Infra red depicts air infiltration from the cold attic and outside down the walls and across the ceiling.

The office attic floor has recently received thicknesses of fiberglass batts and is estimated to be an effective R20-22 with areas of lesser values.
The garage has an impressive amount of 6" EPS under the roof, but again, insulation is not continuous and there are ample areas for infiltration.

Heating and Ventilation Equipment

The 15 yr old Burnham boiler discussed in the Turner Report has evidently been replaced by a Weil Mclean 485MMBtu unit with AFUE of 85%.
Distribution remains inefficient and with varying degrees of inefficiency.

Some exhaust fans exist in the building, though inadequate to remove contaminants, odor, or provide adequate fresh air.

Other Electrical Loads

The offices are equipped with standard office equipment: computers, printers, fax machine, copier, phone chargers, and some kitchen appliances. Garage maintenance and repair involves a range of special equipment with substantial electrical demand. As always tracking use per device or appliance is recommended to be able to make informed replacement decisions as well as be alerted to a malfunction of the equipment.

Lighting consists of 24 (2x) 8' T12 fixtures in the garage and eight (x) 4' x T12s.

Turner Report Recommendations – Summary

The Turner Report assessment and summary is particularly relevant to this energy assessment and report. Many of the observations are outside the scope of this study, yet there are far more areas which overlap. The following summary is offered.

A significant amount of cracking in the blocks was observed and at least in part attributed to frost heaves due to the lack of a frost wall. Recommendations included:

Pointing, repairing cracked and broken blocks and other structurally related repairs, as well as adding steel pipe bollards along the front of the building

Replacing rotting wood trim and painting exterior walls;

Upgrade the bathroom to be ADA compliant;

Upgrade or replace existing fire alarm system and older electrical panels; and

Renovate the break room and replace lockers

More direct energy related recommendations include:

Replacing the shingles on the garage roof with a standing seam metal roof in the next 4-5 years (before 2015) and "the addition of rigid insulation, providing the existing roof structure is capable of taking some additional snow load");

Replacing carpeting and other floor surfaces throughout the administration wing;

Adding insulation above the Administration Wing;

Replace the boiler

Consider a ventilation system to exhaust fumes from the garage.

In sum, opinion of short term costs of $133,500 and mid term costs of $55,200 total expenditures of $188,700 within the next 4-5 years or prior to 2014. The final recommendation was to create a long range plan for expansion, potentially on a new site which does not have as many existing infrastructure and site constraints. Their overall conclusion described the size constraints of the existing garage structure and multiple inadequacies of the existing administration building "making this facility a prime candidate for a major overhaul."

S.E.E.D.S. Recommendations

From an energy conservation and efficiency, and overall building performance perspective, this assessment reaches the same conclusion that a major overhaul is indicated. While all the municipal buildings could use some improvements, in terms of overall working conditions including air quality, safety, comfort and space constraints, the DPW facility ranks last.

In regards to larger issues of sustainability, the S.E.E.D.S. perspective is to always consider retrofit and adaptation of existing buildings, even if for a different use. With that in mind, the ultimate conclusion of this assessment is that even with a major and very expensive overhaul to create a healthy, durable and efficient structure, (even up to the standards enjoyed by every other town department) the administration wing will still not provide adequate space. The recommendation is to either locate to another existing or new building site, or demolish the existing wing and build a modest but high performing building from scratch.

The usefulness of the garage, according to the Turner Report, is highly suspect due to the fact that it is not large enough to house all equipment, nor even to fit specific equipment.
"The fact that many pieces of regularly used equipment are out in the cold means many extra man hours spent on cold weather start-ups." (page 7) The heating and ventilation needs for parking equipment only is substantially different than the heating and ventilation needs for a staffed maintenance and repair shop. Since S.E.E.D.S. expertise is in issues of energy and sustainability, and NOT the work flow, operations and management of a PW facility, the following opinion is offered as a "what if" scenario:

What if the existing garage could be structurally repaired and minimally insulated to be able to maintain near but just above freezing temperatures in order to act only as sheltered equipment storage for as much of the fleet as possible, while a new facility was constructed to serve larger equipment with several repair bays and a maintenance area? This structure would be heated and ventilated for human comfort and safety and sized to serve, in conjunction with utilizing the existing eight bays, the remainder of the fleet and sited to be able to expand in the future if and when that is deemed necessary. The new administration building could be located near or even adjacent to the new garage, but should be a separate structure, at the very least separated by a fire wall, and served by its own heating distribution and ventilation system. The Director made a convincing case for the benefits of having the two next to each other, even sharing a break room and other facilities, but there is no better way to separate the air between two building uses than to physically separate the buildings.

In spite of the above conclusion opinions and recommendations, below is a list of recommendations for meaningful reductions of energy and improvements durability and overall working conditions of the existing facility. Estimated costs offered when they can be somewhat reliable.

1. Excavate, very carefully, around the entire perimeter, to the depth of the bottom of the slab and four feet from the building. Coat the edge of the slab with a water barrier such as Tuff N Dri, and secure a below grade rigid insulation such as Warm N Dri. (Concrete Associated Coatings in Manchester is a skilled contractor). Lay 4' width of 2" rigid XPS as a skirt around the entire perimeter. Add drainage pipe if none exists and refill ditch, with 12" strip crushed stone at the building's edge. The intent is to a) improve drainage of water from the building; b)

reduce moisture intrusion at the slab edge; and c) insulate the earth as frost protection as recommended for monolithic slabs in cold climates.

Excavation, drainage and back fill N/A
Moisture and Insulation barriers $2,800

2. Then make structural repairs as indicated in the Turner Report.

Cost opinion in Turner Report $12,100

3. Insulate the exterior block and walls of the entire building with two alternating direction layers of 2” XPS rigid foam (R20 continuous). Tape seams (Remove all T-111 first.) Secure furring strips and side. Estimate based on T-111 or other inexpensive siding material. Re-frame window openings and use advanced air sealing and flashing techniques.

Estimated cost: $22,000

4. Air seal all ceiling penetrations in administration wing. Foam over top plates and up to propa vents to create an effective air barrier as well as improved insulation over walls. Replace or re-install insulation so that it is in direct contact with an air barrier at the ceiling plane. Cellulose is recommended over fiberglass. Create a minimum effective R40.

Estimated cost: $2,600

5. Remove shingles on garage and inspect roof sheathing and structural components and upgrade as necessary to handle increased snow loads. Install 6” XPS Nail Base Foard Foam Panels (R30 continuous), strap, and install standing seam metal roof as also recommended in the Turner Report. Make sure that the rigid insulation on the walls meets and is fully sealed with the insulation layers on the roof. Roof venting can happen above this insulation layer.

Estimated cost: $126,000

6. Gut wall between offices and garage, seal all penetrations, and spray 2-3” foam in cavity. Cover with 5/8” paperless rock board. Gasket seal the door in the break room.

Estimated cost: $3,900

7. Install a properly sized Energy Recovery Ventilator (ERV), with associated ducts to handle the office and break room only.

Estimated cost: $4,200

8. Seal cracks and gasket all eight overhead doors and end steel door.

Estimated cost: $800

9. Replacing them with high efficiency fixtures able to withstand cold and fluctuating temperatures is recommended. N/A

Total costs for items 1-8 $174,400

At this point the design heat load for the office building is under 15,000 Btu/hr.

While a full HVAC system design is outside the scope of this report, the equipment loads would be very small and the best approach would have to be analyzed. One very efficient approach would be an air to air heat pump to serve the admin building only, which could provide cooling and heating and be integrated easily with the ERV duct system.
Rough estimated cost $15-20,000.

The estimated design load for the garage can only be estimated in its nighttime, non use mode, so it has somewhat less value, but is roughly estimated at 150,000 Btu's. Open garage doors of course cause tremendous heat loss but in reality, it is estimated that they are open less than 5% of the time.

One good heating option would be propane fired Schwank Infra Red radiant tube heaters, the Ultra Series. Two or three 150,000 Btu units should work well in this "new" building at approximately $5,000 each. There are three major distributors in the USA for this Canadian company and Schwank was hesitant to be too specific about pricing. SEEDS' research indicates that this very well insulated building could be heated for a system cost under $15,000. Advantages to these infra red tube heaters include: 1) these are direct vent or sealed combustion, removing at least one hazard 2) the equipment and slab act as a thermal mass to store the radiant heat 3) the heat is distributed more evenly than with forced hot air or other box radiant equipment. This type of heating system is used in garages and highway departments in other NH towns and proves to be very efficient and effective heating devices.
Rough estimated cost: $15,000

The $35,000 sum total of these two systems is just under the $38,000 sum total of Turner's boiler replacement and distribution upgrades – which did not include improvements or cooling in the office. This is only possible because of the substantial envelope upgrade and of course further analysis and equipment design would be required. However, this preliminary assessment is within a reasonable margin of error ball park to decide whether to pursue the strategies more.

The energy load reduction following envelope and system upgrades, which also involves converting to propane and electricity, could be expected to be 60-75%. This is largely due to insulating the garage walls and substantially improving the effective insulation levels everywhere else. Increases in equipment and distribution efficiency are significant but of lesser impact than the envelope upgrade. An end energy use of less than 250MMBtu's or 51KBtu pr sq ft and savings in excess of $10,000 a year could be expected. It should also be noted that ice dams will be nearly or completely eliminated as well as the drainage/drying plane behind the siding will dramatically extend the life of painted surfaces.

Finally, the same insulation strategy would be recommended for the garage building were it to become used as a vehicle storage facility only. This would allow for a phased approach for a future expansion to a new garage building.

The remaining items from Turner's Report, not covered in the estimates above total $79,100, making for a Total overhaul cost with substantial energy upgrade estimated at under $300,000.

Phase II Recommendations

The only envelope component which has not yet been fully addressed is the office slab. If the building were to be used long term, I recommend systematically insulating – and moisture sealing – the slab with 2" rigid XPS under any new floor surfaces. This will reduce heat loss as well as moisture loads and will extend carpet life as well as reduce risk of mold. In fact, carpet is not a recommended slab or floor covering. Tile or wood, over an insulated, moisture sealed slab, is more comfortable, easier to keep clean, longer lasting, and looks better for a far longer time. This is presented in Phase II in part because floor surfaces have recently been replaced. But it would be best if this were integrated with the ADA compliance and other renovations.

Fire Station

Turnpike Road
Energy Assessment

Building Description and Energy Consumption

The Fire Station building was built in 1991. It is an overall 70'x120' on slab on grade. The garage bays to the east are approximately 70'x67' with a ceiling height of 18' and four overhead doors on the north and two overhead doors on the south side. The western section is approximately 70'x57' with a ceiling height of over 14', several double entry doors and six double hung thermapane windows.

Oil consumption for space and water heating has averaged 2846 gallons over the past four years, though less than 2300 gallons used for the '09-'10 heating season. Electric consumption was 35,320 KWH for a total building site energy use over 518MMBtu's and index of 61.6K/Btu per sq ft /year. Total energy costs for the year were $10,990.

Since 1991, replacements and upgrades have been completed to the roof, office and meeting areas, heating and ventilation equipment, and overhead doors. All T12 lights have been replaced with T8's since the 2009 Turner Report. Except for the number and condition of electrical appliances, much of the main equipment and building is still well within its life span so opportunities for energy efficiency upgrades based on conventional economic analysis are very limited.

Envelope Assessment

The structure is 8" concrete block with 4" brick veneer and a flat steel roof. Presumably, an air space exists between the block and the brick but there do not appear to be weep holes at the base. In fact, there is mortar evident between the bottom brick edge and the slab foundation. The block walls do not appear to be insulated in the IR scan, nor was insulation observed in a 3" vent hole in the brick., though there were notes in the plans referring to 2" rigid foam on the exterior. It is the opinion of this assessment that that did not happen and the walls are the single largest source of heat loss in the building, carrying an estimated design heat load of 170,000Btu's/hr or 55% of the envelope's heat load.

The PVC roof membrane was replaced in 1999 as a 20 year roof with 15 year warranty (four years remaining). Each roof has its own drainage pipe to the asphalt surface at the base of the building. Drain grates on the roof were originally installed but have since been removed. A core sample found a remarkable 3" (total aged R17 in two layers) of foil faced polyisocynurate under the liner. While this could certainly be improved, it almost meets the 2009 code and was ahead of its time for 1999. The roof membrane is in good condition and replacement costs have risen over 30% since 1999. Even though its approximate 8400 sq ft is 25% more than the surface area of the walls, its insulation level makes it responsible for only 9% of the buildings estimated existing design heat load (28,400Btu/hr). Therefore adding another 2-4" of rigid foam insulation is recommended, but only when the roof membrane needs replacing anyway. It is therefore not included in the Phase II recommendations in this audit.

The six double hung windows in the meeting room and office were the original windows installed in 1991. They have two panes of glass and may be presumed to have an approximate value of R2 (U.5). Several do not close tightly and all leak considerable air. All frames are thermally conductive. Both the Turner Report and the Chief believe they should be replaced. However, due to the fact that they represent .006% of the total wall's surface area, replacing them with even very high performing windows will have very little impact on energy use. Their biggest impact has to do with air sealing and there are more cost effective and performance effective ways to accomplish air sealing. Replacement windows often still leak air. Installing interior, air sealed, therma pane, fixed storms costs about ½ as much as a replacement and is far more effective. That strategy would require labor and storage for seasonal removal. At this time, there is a window A/C unit in the Chief's office; possibly a reason that window now does not close which would be another reason not to invest in new windows but focus on winter performance strategies.

Air Exchange

Blower Door Testing result for the whole building was 9840CFM50. For a building with a volume of over 126,000 cubic feet, this is considered fairly tight for a building with overhead doors and relatively typical for a concrete commercial structure with minimal window glazing. There is considerable air leakage around doors, windows, and other envelope penetrations, but the size of the building and moisture loads from the bays also reduce drying ability.

A fresh air intake is ducted into the return plenum of the air handling system which serves the offices, kitchen, and meeting room. But it only operates when the air handler is running which limits fresh air ventilation and continues to add outside air even when the boiler is off, which means it can blow cool or cold air at times. It can also have the effect of pressurizing the building which increases heat loss through exfiltration.

In the bays, a Plymovent exhaust system is designed to remove truck exhaust fumes directly from each truck's tail pipe. This is an effective source point exhaust with minimal impact on the air pressure of the bays but also nearly no impact on moisture loads or other contaminants. Separate bath exhaust fans exist in the two bathrooms.

Energy Load Assessment

Heating hot water in the summer appears to use about 200 gallons of oil. Presumably domestic hot water demand in the winter is met mostly through water heated when there is a demand for space heating as well.

Envelope Loads represent approximately 80% of total energy used for space heating. The remaining heating fuel is lost to combustion and distribution inefficiencies. Of those approximate 1900 gallons:

Convective Losses:	Air infiltration	15%

Conductive Losses:

CMU walls	55%
Slab Edge	8%
Roof	9%
Overhead Doors	9%
Framed Walls	3%
Steel Doors	1%
Windows	<0%

As is often the case, the components of the envelope that represent minimal conductive losses contribute the greatest to air leakage and convective losses. While windows and steel doors account for barely 1% of the total heat loss by conduction, they represent a considerable source of air infiltration and exfiltration in the building. Overhead doors have a proportionally larger impact due to their larger surface area and larger air gaps which have a more substantial impact on heat loss and moisture issues.

Significant contributors to air leakage are in bold above.

Heating and Cooling Equipment

Heating system is based on a 483MMBtu Burnham boiler installed in 2000. Inspection tickets report combustion efficiency at 83 ¾% for the last three years. There are three heating zones and the boiler feeds a 35gallon Vaughn hot water heat exchanger. Water temperature range is set to a high of 210º and a low of 170º. Based on current fuel use and this assessment, the boiler is believed to be 20-50% oversized for space heating and excessively oversized for summer hot water supply.

Hot water also feeds four ceiling mounted, fan assisted, Modines in the bays with one thermostat. Two other thermostats control a HydroPac Air Handler with insulated flex ducts running in the chase above the suspended ceiling to offices, kitchen area, and meeting room. As stated in the section on Ventilation, outside fresh air is supplied into the return plenum. The heating system is believed to be responsible for approximately 20% of the heating fuel consumed through combustion and distribution inefficiencies.

Summer cooling in the office and meeting room has been supplied by window mounted A/C units. The Turner Report stated that central air would be more efficient. Despite a hot July, there is currently only one unit installed in the Chief's office.

Other Electrical Loads

Envelope loads impact electrical use as well as fuel consumption. Electricity needed for water pumps, the air handler, and special ventilation equipment is substantial, though beyond the scope of this audit to quantify.

All lighting has been upgraded to T8's as per Turner Report recommendation.

The offices are equipped with standard office equipment: computers, printers, fax machine, copier, phone chargers, but also considerably more electronic equipment associated with the number of people who serve a fire and safety building use, including heavy duty laundry equipment and a kitchen with many appliances. Images and supplemental list are in the visual report.

Turner Report Recommendations Summary

The Turner Report recommendations included re-pointing brickwork; create a drainage swale; install a backflow preventer; install a code compliant stove hood; upgrade bathrooms; replacing ceiling tiles; repair pavement; consider re-coating floor surfaces and installing a separate bath and locker room.

More direct energy related recommendations:

Install new energy efficient, double hung windows in the meeting room
Replace the steel man door at the south side of the station (2-3 years)
Seal and caulk all penetrations through the brick
Weatherproof and caulk around the overhead doors
Upgrade the lighting in the equipment bay to more cost effective, energy efficient fixtures.

SEEDS' Recommendations

1. Install heavy duty weather-striping to all steel doors and exterior doors. (#4,#2)
Estimated cost: $1,600

2. Install removable air sealed therma pane interior storms on five windows and permanent air sealed therma pane interior storm panels on two fixed side lights at entry. Remove the window in the northeast storage room and in fill with an effective air barrier in direct contact with effective and continuous insulation and appropriate finished surfaces. While daylight is helpful, the room is rarely used and the window serves no view or fresh air purpose – its primary function is winter heat loss and summer heat gain.
Estimated cost: $1,300

Estimated savings from #1 & #2: 120-150 gallons oil; 2800 lbs carbon and at least $325/yr

Of course, arguments can be made for window replacement (#1); just not from an energy conservation perspective. If windows are to be replaced, it is recommended that the whole unit is replaced, not just sashes, and that they are foam sealed into their rough opening for optimal improvement. Alternately, replace all six windows with new quality window units with a maximum U.3 and SHGC.4 glazing. Frames should be thermally broken.

(Estimated cost: $3,500 – not included in total below with equal or reduced savings)

3. Install Flat Plate Solar Hot Water system on lower roof and connect to new and existing storage tanks with heat exchange. Estimated cost: $7,500

Estimated savings: 200 gallons oil; 4500 lbs carbon; at least $518 annually

Equipment Recommendations

4. Especially after air sealing; an HRV in ceiling of room between boiler room and apparatus bays. Duct the balanced ventilation system into offices and meeting rooms and disconnect fresh air supply to air handler's return plenum.

Electrical Recommendations

1. Purchase a Watts Up Meter and monitor all appliance use. Refrigeration (freezing) especially can add significant draws on electricity. Older, donated appliances, can seem like a wind fall, but can add significantly to the energy bill. Replace appliances with Energy Star qualified at a minimum.

2. Move freezer away from boiler and hot boiler room to (windowless, cool) storage room at NE corner. After monitoring use, consider replacing with 2 or 3 smaller, very efficient freezers, and only run them when they are full.

3. Connect appropriate plug in loads (not servers, message machines, or emergency equipment) to power strips which can be turned off at night and when not in use. "Phantom Loads" can add up to a significant electrical draw over time. Use Watts Up Meter for a few days per power strip and track what could be saved if turned off the 72% of a week's hours the building is unoccupied.

Phase II Recommendations

4. Install minimum of 2" rigid (R10) foam insulation on all exterior walls with new drainage plane, air space and exterior finished surface. Roof overhangs would need to be constructed. This is the time when window replacing would be recommended.
Estimated Cost would vary based on finished surface and window selections: $36K-$60K

Estimated savings would also vary depending on human behavior variables but in the ball bark of 500-700 gallons oil and over $1,300/yr as of 2010 oil prices. It is expected that the savings will become considerable higher.

5. After insulating the block walls and all previous upgrades, the design heat load of the building would be 60% lower than it is currently and the boiler would be tremendously oversized. Exploring new heating options, including a pellet boiler would be highly recommended at that time.

6. When the time comes to replace the roof membrane, perhaps in 5-10 years, add 2-4” more foam as part of the capital expense.

Library
Main Street
Energy Assessment

Building Description and Energy Consumption
The Turner Report indicates the Library was built in the 1820's and 1895 is carved on the front over the entrance. Regardless of its exact birth year, what exists is a granite and brick structure built in the 19^{th} century on what was originally a below grade basement and a two level structure built slab on grade in 1990. The front of the historic building faces Main Street slightly west of south.

The 1990 addition more than doubled the floor area to almost 6900 sq ft. The rear of the site was excavated so that the lower level extends from the original basement. Nearly 75% of the original basement remains below grade and is used for mechanical and electrical room, a small kitchen, and storage. The addition was constructed with metal stud walls and precast concrete floors, a brick veneer and a rubber membrane covered flat roof on wood trusses. The lower floor serves as the children's section, offices, and a meeting room. It also houses two bathrooms, an elevator and stairwell. The original building and the addition are entirely open to one another, connected by a 16' x 16' two level section of the original building and served by one boiler through multiple distribution systems.

The attic of the main part of the original building has a fully decked, multi leveled floor. It is accessed by a steep staircase and was used for storage in the past. The roof is a complex steeply slope wood frame with four gables and sheathed with wood planks and covered with slate. The roof and attic are minimally vented by gable end windows and several holes added into the soffit and patched over with screen.

The attic space over the addition consists of truss framing and exposed fiberglass batts resting on strapping, a layer of plastic and a chase above a suspended ceiling. The elevator and three vent stacks penetrate through to the flat roof above.

On average, nearly 4000 gallons of oil are used to provide heating to the building; just over 41Kbtu per sq ft. Electrical consumption from June '09 to July '10 was 53,440kWh. Total site energy averages 54.7KBtu/ft sq. For the same period, dollar cost for heating oil was $8,734 and electricity $8,964 for a total energy cost of $17,698 or $1.31 sq ft.

Air Exchange
The building tested at 16,825CFM50 which, based on the total building volume, translate to 8.44ACH50 and an estimated winter air exchange rate of .96, or almost once every hour. These results include the existing fresh air openings because that is a real life condition.

Besides the cabinet heater/ventilator openings, the primary sources of air infiltration are doors, windows, and the lack of an air barrier in the attic floor of the 1990 wing.

Envelope Assessment

A simple spreadsheet heat load calculation, with blower door test results and estimated values for all components of the envelope, indicates an existing design heat load of 262,283Btu's per hour with a design temperature of 68º. That means that if it 0 degrees outside, it would take 280,447 Btu's worth of heat every hour to maintain 68 degrees in the conditioned space. That would then typically inform the size of the equipment: to be able to deliver just enough heat for the coldest night of the year but operate efficiently every other hour of heating season.

Typically, a 'design temperature' is based on the coldest temperature reached for over 98% of the year. In reality, systems are usually installed to satisfy the heating load for the very coldest night in a decade and then another 15-30% is added as a fudge factor. No heating contractor wants to be called on a freakishly cold Christmas eve because the house can't get to 70 degrees for the family reunion. Consequently, the EPA estimates that heating equipment in this country is 50-150% oversized for the building and the climate its in. Properly sizing equipment is fundamental to an energy efficient system.

In the Heat and Ventilation Assessment attached, Doug Waitt's more conservative estimated heat load calculation is 300,000 Btu. That's in the same ball park for two fairly simple calculations and making both useable numbers.

Each component of the envelope has a particular share of responsibility for heat lost in an hour. Based on my estimations, the envelope breakdown is as follows:

	Btu's per hour	% of total design load
Granite and brick walls (original building)	23,984	9%
1990 walls	22,099	8%
Old windows (original building)	10,332	4%
1990 windows	10,660	4%
1990 ceiling	15,189	6%
Original 2nd floor ceiling	8,563	3%
All exterior doors (including entry)	6,601	2%
Below grade foundation walls	18,480	6%
Air infiltration (includes fresh air venting)	119,253	49%
Total	280,447 Btu/hr	100%

This 'distribution of responsibility' can help determine how to prioritize improvement efforts. Equally useful is to project improved conditions to see the reduction in each component and for the load as a whole.

For example, if all the recommendations made below were to be completed, the heat load calculation might look something like this:

	Btu's per hour	% of total design load
Granite and brick walls (original building)	23,984	13%
1990 walls	22,099	12%
Old windows (original building)	7,188	4%
1990 windows	10,660	6%
1990 ceiling	4,388	2%
Original 2nd floor ceiling	2,093	1%
All exterior doors (including entry)	6,601	2%
Below grade foundation walls	18,480	10%
Air infiltration (includes balanced ERV)	67,560	38%
Total	203,619 Btu/hr	100%

Typically, the next step is to run that design load through a Temperature "Bin Analysis" or a projection of how many hours in a heating season will fall in a particular temperature range. For example, there may be 42 hours each winter when its 0 outside and you will need those 203,619 Btus to maintain a 68 degree inside. But that same building will only need 99,000 Btu's to maintain 68 degrees inside when its 30 degrees outside – and there may be 800 hours of 30 degree temps in Jaffrey in any given winter! It is this step which can help project total heating costs; when you also know how efficient or inefficient your heating equipment generates and distributes heat through the building.

Please note that there is the science of thermodynamics and mathematical formulas at work here; but there is also the art of assessment and subjective interpretation. For example, there are six inch fiberglass batts in the 1990 ceiling. The bag the batts came in said they had an R-Value of 19. The R19 was determined in a laboratory setting with 6" fiberglass carefully installed in a box at perfect loft and in direct contact with a rigid air barrier on all six sides. What is the effective R value of those batts without an air barrier at all and sometimes as full loft and sometimes squished down to 3"? What about all the surface area which is not insulation, but 6" wood joists? They are an effective R6 or so. But they count! I chose the conservative value of an overall R13 for the ceiling to account for direct air infiltration and for wood joists. The walls of the 1990 wing are even more challenging. Metal studs are excellent at conducting heat and every 16" there is a 1.5" surface in contact with the outside wall and the inside sheetrock. It is the ultimate 8' thermal bridge – every 16". We might think we have an "R11" or "R19" wall, but thermal bridging – and air infiltration - can degrade a wall's performance substantially!

Most energy efficiency reports don't go into all this and probably for good reason. But S.E.E.D.S. middle name is quite literally Education. I believe that we can only make informed choices when we have at least a basic understanding of the options. And I also believe that to provide a responsible assessment of the Jaffrey Library, it is important to at least attempt to describe components of the whole building. This is far more difficult a lesson when assessing a Library which completed a beautiful new wing a few years before. My experience has been that the original, historic and beloved building often holds heat better than the brand new, code compliant, multi-million dollar addition they just finished! If for no other reason than granite or masonry buildings are generally tighter than conventional stick built – and 14" of granite or brick ends up having a very similar overall heat loss value of a 6" fiberglass wall with thermal bridges every 6 inches.

The intention here is to attempt to break through assumptions we may have had about construction practices and energy performance. Reducing energy use is about making informed choices based on costs and impacts. Clearly the biggest source of heat loss in the building is through air infiltration and active ventilation. The biggest holes are doors and windows – the old and the new! They are actually "similarly leaky". It is my understanding that there is no interest in replacing the historic windows and the cost of replacing the newer ones would have a very long pay back. Air sealing all of the existing windows can be cost effective and installing interior custom, wood, thermal pane storms over all single pane fixed windows will impact both conductive and convective heat losses, for a relatively cost effective procedure.

Converting the heating equipment and distribution system will have a similarly significant impact and many people choose to just do that. The primary reason for this rant on thermodynamics in buildings and the math is to demonstrate, with Doug Waitt's financial analysis packet, the wisdom and dollar value of improving the envelope before installing a new system and sizing that system for the improved envelope!

If the above heat load scenarios hold true, then a new heating system could be almost 28% smaller than before any envelope upgrade. That could save $10-25,000 or more on some heating systems, as well as reduce energy use every year moving forward. This is important to factor when looking at the costs of the improvement. If you install new heating equipment, you can optimize the upgrade by first investing in meaningful envelope improvements.

One more topic: Moisture. Much of the dampness in the lower level (and many NE buildings) is due to air leakage from the above grade areas. Warm moist air migrates into earth bermed, cooler areas, is cooled to the dew point and water forms. Air sealing will reduce moisture ladened air. In addition, the earth is always wet (wettish) and that moisture will always migrate towards drier conditions – eventually making them equally damp. Insulating foundation walls with closed cell foam stops moisture migration as well as slows to stops inside heat moving the cold or cool earth. Note the heat loss associated with below grade foundation walls above. Finally, as the building is made tighter, it becomes increasingly important to manage moisture levels on the inside. Air sealing and insulation (thwarting the dew point) become passive strategies. Dehumidification and ventilation are also effective strategies but require energy input.

Heating and Ventilation Equipment

A more detailed narrative description of the HV system is attached from Doug Waitt of Design Day Mechanicals. A brief summary is offered below.

There are two oil fired boilers certified by HydroTherm Inc. with a total heating capacity of 502KBtu. The boilers are over 20 years old. Single zone continuous flow hot water serves a variety of distribution strategies.

The original building is heated by a single fan and three duct mounted coils. Each floor has a thermostat which regulates the amount of hot water and warmed air distributed to the space. Outside air is ducted into the single return plenum of the air handler, all located in the boiler room.

Both levels of the newer wing are heated and ventilated via floor mounted cabinet units. The boiler provides continuous hot water through each unit and a space mounted thermostat regulates the amount of heat by adjusting the flow of air across the hot water coil. Three of these units have outside air intake louvers to supply continuous fresh air offset by four roof mounted exhaust fans. The unit in the main level stack and reference area runs 24/7, 365 days a year. The other units provide heat only.

Hot water convectors, fin tube radiation, and a single kick space heater, also with continuous hot water flow, supply heat to bathrooms, the kitchenette and offices.

Interviews with staff indicate that temperatures vary throughout the building; some areas too hot or too cold in the winter. The original structure is generally too cold as are corners of the main stack room. The dial style thermostat is set to "65ºF" and never moved. During the testing site visit, it was 37ºF outside. The room temperature near the main level thermostat measured 71.8ºF. A corner closet, former bathroom, on the third floor was over 84ºF. The building is hot in the summer and the third floor is very hot and poorly ventilated.

The library is open weekdays with varying times and Saturdays from 10am to 2pm for a weekly total of less than 40 hours or 24% of the time.

Other Electrical Loads

Heating and ventilation distribution dominates the electrical load for the library, though lighting is believed to be a significant factor. Public computer stations and staff office and kitchen equipment are depicted in the visual report.

Turner Report Recommendations (paraphrased) Summary

Recommendations address replacing finish surfaces; re-plumbing a doorjamb; re-configuring the second level; providing oil containment; and adding a ADA required strobe light.

More direct energy related recommendations include:

1. Address water intrusion through improving the gutter system, regarding, and installing a drip edge.
2. Install an air lock at the main entrance.

3. Add insulation in the attic. “Prior to adding insulation, an engineering analysis of the existing roof structure should be undertaken to determine if the added snow load that can be expected when more insulation is installed, (will) not pose a problem for the existing framing members.”
4. Replace older exit signs with efficient LED lit signs.
5. Conduct an-in depth HVAC system and eventually replace the boilers with more efficient models.
6. Relocate ventilation fans and ductwork outside the boiler room.
7. Provide a cabinet heater in the front stairwell

SEEDS’ Recommendations
1. Professionally install weather stripping to all exterior doors. Woodworker now refinishing the front door assures me he will be doing this for that door, as well as rebuilding the latch so it closes firmly.
Estimated cost $600

2. General air sealing: wall outlets, light switches, hatch and door to attic, basement areas – all as identified in visual report.
Estimated cost: $275
3. Fully concur with Turner Report importance of addressing water intrusion as part of improving the performance of the building envelope and concur with the strategies described.
Turner opinion $11,500

4. Air seal and upgrade insulation (#9) in the original attic. The most comprehensive approach would be to remove all or some of the existing decking and insulation and spray a skim coat of closed cell foam to establish both an air barrier and a vapor barrier at the same time. It is likely that such an approach would be very expensive and that a lesser strategy conducted by highly skilled, informed, and performance motivated contractors could create an effective air barrier in a more site specific manner. The center dais, over the raised ceiling below, however, should be at least partially removed to inspect the back of the ceiling surface and sealed and insulated carefully with either cellulose, open or closed cell foam, to a minimum R45.
Ballpark estimated cost: $6,200

5. Establish an air barrier in the ceiling over the newer wing. Increasing effective insulation levels will also reduce heat loss, but the most important upgrade opportunity here is to stop air from contacting the fiberglass. This area is also complex with no straightforward or inexpensive solution because there is no rigid ceiling or floor surface to seal. While of minimal cost during construction, creating a solid floor or ceiling after the fact is labor intensive and costly. Without an air barrier, the existing ‘code compliant’ insulation levels are performing at only 20-60% of their stated R value and air leakage denotes a direct connection to outside. One approach would be to lay a 5/8” plywood floor directly on the horizontal truss members. This will require patching around vertical members as well as cutting around, then ceiling, cables and wires. Tape all seams and foam seal around perimeter and elevator chase. Then blow in 8-10”

cellulose to achieve a near R40 ceiling. Spray 4" foam onto the exposed slopes of the original roof.

Ballpark estimated cost: $5,550

6. Windows:

a. Install permanent interior, therma-pane storms over all fixed pane windows. Also install custom built interior storms to corner closet in 3rd floor which previously served as a bathroom, ($3000)

b. Install removable but sealed interior custom built therma-pane windows on all windows which are never opened. Exterior storms could be removed (as opposed to trying to fix them) ($4800)*

c. Retrofit old windows and replace rope and pulley with load bearing balanced spring devices. ($3,600) Awning windows have turning handles but do not have a lock to seal closed. Install a latch which seal closed the window and weather-strip. ($450)

d. Install therma-pane fixed window in front door. Woodworker currently refinishing door said it could be done most acceptably on the inside. He assured me he would be weather-stripping the door; which would have been recommended here. ($345)

Total window estimate: $12,195

*b. Alternate: Fix or replace exterior storms for better seal and functioning. ($1900)

Alternate Window total $7,395

6. Install programmable thermostats for nighttime and weekend set backs. The improvements above will speed up recovery time in the morning and set backs will optimize energy savings.

7. Spray 2" closed cell foam on all below grade exposed stone foundations and paint with intumescent paint for a 15 minute flame barrier.

Estimated cost: $3,200

Estimated Energy Reduction on items 1-7.

The estimated impact of these envelope improvements and setback thermostats in the existing heating system would be to reduce fuel use between 17 and 20%. They would also allow for a quicker recovery time so that programmable thermostats could be installed for very little money but an additional 5% energy reduction. Which creates a 15-25% reduction. Equally important, they could result in a 20-28% size reduction of future heating systems which would save on both up front costs which improves the rate of return on investment.

8. Install a single on/off switch for all public computer power strips (one on the main level and one on the lower level) so that they can easily be turned on at opening and off at closing time. Also turn on and off office computers which do act as a server.

Estimated cost: $175

9. Lighting: Replace older Exit signs with more efficient LED models. (#11)

In addition, there have been significant advances in energy efficient lighting technologies and far more are on the horizon. Lighting requirements for a library are a specific niche and is not an expertise within S.E.E.D.S. At the time of this report, I do not have confidence that I can offer the best opinion on the existing lightning nor advice on the kind of fixtures which would offer a significant improvement. There are just too many new directions and too many conflicting "expert" opinions. The recommendation is, (just as with many other municipal building electrical loads), to install a data logging device onto lighting circuits to measure how much electricity is used for lighting for each area. Two to three months over the fall or spring is a good time to conduct this study. Only when the true costs can be assessed can the savings for replacements be accurately projected. And only time will help sort out the performance of the new technologies. If the promised performance proves true, they will be worth the wait.
Estimate N/A

10. Significant savings and improved comfort could be realized through an entirely new heating system design. (#'s12-14) A more efficient cold start boiler with programmable thermostats and balanced ventilation with heat or energy recovery could reduce fuel use 20-30% or more. Since an overhaul of the existing equipment may be in order, it seems prudent to examine converting to another energy source and possibly a heat pump system which could also deliver cooling.

An overview of the existing system and several replacement options is attached from Doug Waitt. Options explored are 1) Oil fired boiler 2) Wood pellet boiler 3) Ground source heat pump 4) Air to air source heat pump and 5) Air to air heat source pump with on site PV generation to provide approximately 40% of heating system demand through solar generated energy. Each system is accompanied with projected heat loads, dollar savings, and a preliminary financial analysis. Please note that this level of analysis is intended to help select a system and energy source. Further design and a comprehensive heat load calculation and or energy modeling would be required for a complete system design.

Estimate N/A – Analysis attached

Police Station

26 Main Street

Energy Assessment

Building Description and Energy Consumption

The Police Station is a brick and masonry structure building built in 1954. The building foot-print is approximately 38' x 58' with a one story 20' x 38' garage port added onto the NE side in the mid 1990's. Its overall floor area is about 5160 sq ft. There are two levels to the main building: the main street entry floor and a lower level which is 50% below grade. The garage port extends off the northeast wall at grade. A wood framed hip roof is over an eave vented attic. Vents are 2" round soffit vents spaced less than 2' apart.

The main building is heated with a 216MMBtu Weil McLean boiler hydronic baseboard. Fuel used is #2 and a kerosene mix and the four year average consumption is 1373 gallons for space and water heating. Hot water used is minimal and heated through an indirect 30 gallon SuperStor heat exchange tank and boiler. The car port is heated by a 40KBtu oil fired Modine heater mounted on the ceiling of the north east exterior wall. Electric consumption was 46,056 KWH from June '09 - May 2010 for a total site energy use over 349MMBtu's and index of 79.4/Btu per sq ft /year. The total energy costs for that year was $9,830.

Air Exchange

Blower Door Testing result for the whole building was 3,887CFM50 and 5.57 air changes per hour at -50 pascals. Continuous exhaust from the lower level occurs through an inline fan in the attic. A second in line fan presumably exhausts from the upper level. (220 and 400 CFM) Registers were not taped for the blower door test suggesting the building envelope is actually tighter than indicated by 3887CFM50. This is not uncommon for a masonry structure, even with considerable air leakage through windows and doors. Moisture loads from below grade wall, slab, and strong connection to the garage port are a mild concern at present; effective air sealing to reduce heat loss will elevate the risk of high interior moisture.

Energy Load Assessment

Envelope Loads represent approximately 60-70% of total energy used for space heating. The remaining heating fuel is lost to combustion and distribution inefficiencies of the heating system(s). Of those approximate 800-960 gallons, it is estimated that :

Convective Losses: Air infiltration 23%

Conductive Losses:

Above grade walls 15%

Below grade and slab 14%

Sally port walls 25% (HLC) Main ceiling floor

9%

Overhead Doors 8%

Sally port ceiling 2%

Ext Doors	3%
Windows	7%

Significant contributors to air leakage are in bold above.
Estimated total Design Heat Load: 111,841 Btu/hr with a 66 design degree
As is often the case, the components of the envelope that represent minimal conductive losses contribute the greatest to air leakage and convective losses. While windows and exterior doors account for barely 7% of the total heat loss by conduction, they represent a considerable source of air infiltration and exfiltration in the building. Overhead doors have a proportionally larger impact due to their larger surface area and larger air gaps which have a more substantial impact on heat loss and moisture issues.

Heating and Cooling Equipment
Heating system is based on a 240KBtu Weil McLean boiler and Carlin burner with a multi-zoned hydronic baseboard distribution system. The boiler was tested at 86.6% efficiency. Despite the number of zones, several areas are consistently too hot or too cold. This may in part be the nature of a secured building, where locked doors inhibit air circulation. Thermostats are not set back as the station is staffed 24/7. An (oil) fired 40K Btu Modine heater in the Sally port is operated by a dial thermostat when needed. The heating system is believed to be responsible for well over 0% of the heating fuel consumed through combustion and distribution inefficiencies.

Summer cooling in the office and meeting room has been supplied by window mounted A/C units. The Turner Report stated that central air would be more efficient. Despite a hot July, there is currently only one unit installed in the Chief's office.

Other Electrical Loads
The offices are equipped with standard office equipment: computers, printers, fax machine, copier, phone chargers, but also considerably more electronic equipment associated with the number of people who serve a public safety service building use, television monitor, special testing equipment, and a kitchen with many appliances. Images and supplemental list are in the visual report.

Turner Report Recommendations Summary
Recommendations include exterior painting; explore options to expand storage; upgrading the security system; renovating the bathroom and locker room area; replacing furniture; add strobes to the bathroom, exit signs where required, and GFI receptacles as required by code.

The more direct energy related recommendations include (paraphrased):
1. Replace the front door
2. Replace the floor in the squad room
3. Install air handler system
4. Add combustion air supply; repair boiler leak; add heating zones
5. Redirect heater in the Sally port

SEEDS' Recommendations

1. Replace the steel door between the squad room and the sally port and gasket seal to create an effective air barrier. When you replace the front door (#1) consider a well insulated door with high R value glazing and a very tight seal. Install heavy duty weather-striping to the other station/sally port door and all exterior doors, including the front entry.

Estimated cost: $1,800

2. Gasket and air seal both overhead doors. Close gap at bottom of north door by also patching concrete if necessary.

Estimated cost: $1,600

3. Retrofit all windows so that they close and seal. Professionally air seal and caulk with special focus on lower level awning windows.

Estimated cost: $260

4. Replace all ceiling light fixtures with T8's or other high efficiency fixtures and lamps.

Estimated cost: $3,600

5. Remove television monitor in ceiling corner of squad room and the fan next to it which runs continuously to keep the TV cool. Replace with safe and efficient TV if necessary.

6. Air seal and upgrade ceiling insulation:

Replace or repair folding ladder to attic. Repair edges to be able to be gasket sealed. Remove all existing loose fill and batt insulation. Air seal all penetrations, including new light fixtures. Remove any wiring which is no longer in use and insure connections are safe for insulation. If metal hatch over bathroom is desired, build up walls around it to hold back insulation and install a foam seal insulated box as a cover. Spray a 1-2" closed cell foam layer over entire floor deck to insure a continuous air barrier and a vapor barrier. Inspect perimeter and foam seal framing to masonry wall. If continuing to use as storage is desired, use 2x10's to frame out a new deck height. Cover with 3/4 " plywood. Blow in 18" of cellulose and deck over. Install insulated hatch cover.

Estimated cost: $8,680

7. Clear all exterior walls in the Sally port and remove Modine heater. Secure 2" XPS to exterior walls, leaving a 1" gap to the slab. Screw 2x2 studs through foam into block. Cover with paperless rock board. Replace louvered vents to exhaust fan so that they close securely. Re-install Modine heater (#5), potentially on interior shared wall, and direct into room

Estimated cost: $1,800

8. Air seal all penetrations in ceiling and upgrade insulation to an effective minimum R40. Foam seal to top of new insulated foam wall at perimeter.

Estimated cost: $1,850

Equipment Recommendations

9. As stated in the Turner Report: Add Zones to the Squad room and the chief's office to eliminate overheating. (#4)

10. Remove exhaust in line fan systems and install two residential scale ERVs to provide adequate fresh air ventilation to both levels with energy recovery, such as Venmar or LifeBreath. Install CO monitors for each level to regulate amount of fresh air required at any time and any closed space, such as the meeting room. If one of the ERV's has to be installed in the attic, create a small insulated room for the unit and the ducts. This is respectfully suggested instead of an air handler unit (#3) because it will provide year round fresh air ventilation more efficiently and with less duct work. Also, the recommendation for the heating system is to explore an air to air heat pump at the time of replacement. Allow a season or two to evaluate envelope upgrades in the station and sally port, as well as added ventilation and zones to assess hydronic heating potential as well as modified cooling needs.

Estimated cost: $5,000

Estimated Energy Reductions:
Lighting upgrade will reduce electric bill 35% of existing lighting load. For accurate savings projection, install HOBO data loggers on lighting circuits for at least one month in the fall.

Estimated fuel reduction from air sealing and other envelope upgrades:
35% of envelope load heating fuel energy or 375 gallons and $815/yr.

Phase II Recommendations

11. Insulate all lower level block walls with rigid XPS foam board and SPF where needed to R10. Estimated $2900

12. Prior to any floor removal or replacement (#2), lay a minimum of 1" XPS on slab and tape seal all joints. This is for insulating value but also to block all moisture.
Estimated $5,000 (in addition to new flooring)

13. Replace boiler with properly sized high efficiency, modulating, condensing propane boiler; or consider other fuel or energy source at the time. With reduced envelope loads an air to air heat pump would also permit efficient cooling if it's still deemed necessary.

Estimated Range: $12-25,000

Equipment Upgrades:
Improved Design Heat Load will be approximately 73KBtu/hr.
Requiring heating system capacity approximately half the size of the existing boiler.
Improved air quality and 10-25% further fuel reductions or 200 gallons.

Recreation Department

Office and Garage

Energy Assessment

Building description and Energy Consumption

Total building on site energy use is 212MMBtu's or 130KBtu/sf. This is skewed in that one meter also serves the rink and other buildings. The building is heated by a propane fired hot air furnace, a propane fired ceiling mounted radiant heater and at least two electric space heaters. Total heating propane fuel energy use averages at 83.3KBtu/sf., but total heating energy cannot be assessed without electric use for space heaters.

The building is approximately 24'x68' with 2x4 walls and 2x6 ceiling rafters. As described in the Turner Report: "The original metal building was 44' x 24' and constructed at NH Ball Bearings then moved to the present site in 1990/1991 (onto an uninsulated drain with presumably no foundation drainage). The original flat roof was removed and a new wood-framed gable style roof was added. In 2000, a 24'x24' wood framed section was added (on the east side of the) original building…"

The building is currently divided into three functional sections. A 22'x24' office on the west end, heated by overhead duct work from a Rheem FHA furnace; a 22'x24' middle room used for activities, storage, and the location of the furnace and water heater; and the 24'x24' repair and maintenance garage built in 2000, which is heated by the ceiling mounted propane fired radiant heater. The return plenum opens into the director's office on the other side of the furnace wall. There are doors between the sections, though they are often open and when closed are not air tight. Each section has its own distinct insulation strategy and performance.

The building has used a yearly average of 1204 gallons of propane for space heating for the past three years, though only 970 gallons during the '09-'10 heating season. Several improvements were made prior to the '09-'10 heating season; some based on the findings and recommendations of the Turner Report. These included replacing the 12 year propane fired water heater with a 40 gallon, 4500 Watt Reliance electric hot water heater. This would likely account for at least some of the fuel reduction this past year. The total department cost for the year $7,933.

Air Exchange

Three separate blower door tests were conducted:

Office only, registers tape sealed: 1862CFM50 and 17ACH50

Whole building, registers tape sealed: 5329CFM50 and 15.07ACH50

Whole building, registers open: 5475CFM50 and 15.48ACH50

Dimensions were adjusted for each result. What can be learned from this and other pressure diagnostics is that 1) the building is very leaky. 2) All three sections are very leaky to the outside, but more, they are entirely connected to each other 3) The ducts in the ceiling have some air leaks: enough to seal the connection to the registers, but probably not enough to replace 4) There was a tremendous amount of air moving through the walls and mesh holding fiberglass; perhaps no more than from the walls and ceilings of the two bays, but the slightly enclosed area and loose fiberglass was significant. 5) Air infiltration may be responsible for as much as 32%-40% of the heating bill.

As is often the case, the components of the envelope that represent minimal conductive losses contribute the greatest to air leakage and convective losses. While windows, doors, and the end garage door only account for approximately 5% of the total heat loss by conduction, they represent up to 40-50% of the air infiltration and exfiltration in the building. In this building, there is also a lot of air leakage around wall and ceiling framing.

Significant contributors to air leakage are in bold above.

Envelope Assessment

Office: Wall cavities have 3.5 fg batts behind drywall effectively performing between R6 and R7. Above the dropped ceiling, there is no dry wall to stop air or hold the batts in place and the walls perform poorly – effectively less than R3. Above, a wire mesh holds a wavy 4-5" fiberglass. The lack of an air barrier may reduce the R-value of this insulation layer up to 50%. Insulated flex duct serves ceiling heat registers. The western exterior door is metal, uninsulated, with a single pane light and has rust and cracks. The front door is in better condition with a air leaky mail slot.

Middle Section: It appears that there is 3" fiberglass wedged in between the exterior metal siding and an interior metal surface. Air channels reduce the performance of these walls further. The 8x12 overhead door is not insulated, nor used for vehicles or large equipment. Plastic encased 3" fiberglass batts drape the ceiling, held in by sporadic strapping. There are many holes and gaps in this draping and the metal roof can be seen past very dirty fiberglass. The insulation is acting more as a filter than slowing heat loss. Air leakage is evident throughout the perimeter. One metal duct with several registers runs along the north wall ceiling.

Garage Section: Walls are mostly sheet rocked over 3.5" fiberglass batts. Exposed 5.5" faced batts are hanging between 2x6 ceiling rafters and likely in partial contact with the roof sheathing. The garage door is insulated to a guestimated R4. It was reported that this section appears to be 'more efficient' than the rest of the building in that heat 'stays longer.'

The Turner report also indicated that "the shingles over the original 44' section of the building are in fair condition and should be scheduled for replacement in the next few years." This provides an opportunity to explore options for a substantial energy upgrade by insulating the roof at the time of shingle replacement.

The building was partially flooded in the winter of 2008. As a result, some drywall, wall insulation batts, and the office flooring have been recently replaced. Unfortunately, the replacement missed an opportunity to insulate the slab floor and foam seal the bottom plate which would help eliminate the need for electrical space heating. Making energy upgrades at the time of renovations or capital improvements (such as roof shingle replacement) is strongly recommended throughout the Town's building inventory.

The following analysis is based on the results of the site visit, infra-red imaging, blower door testing, spreadsheet heat loads and bin data analysis.

Envelope Loads represent the remaining 80% of total energy used for heating. Of those approximate 800 gallons:

Convective Losses: Air infiltration 34%

Conductive Losses:

Middle Section walls	17% (includes overhead door)		
Rest of net walls	16%		
Slab edge	8%		
		Middle ceiling	9%
		Walls above office ceiling	7%
2000 ceiling	4%		
Office ceiling	2%		
Windows and Doors	<2%		
Garage Doors	1%		

Heating Equipment

The heating equipment is believed to be responsible for approximately 20% of the heating fuel consumed through inefficient combustion and distribution. Water heating no longer consumes propane.

Interviews with staff indicated the following: The building is staffed by 2-4 people. Office hours are 7:30-3:30 on weekdays and some weekends for planned activities. The thermostats are programmed to the following schedule:

Office and Middle Bay Furnace:

Set to 68 during occupancy and back to 55 from 2:00PM to 6:00AM weekdays
3:00PM to 10:00AM weekends

(week: 50 hours at 68 and 118 hours at 55)

Two under desk electric space heaters supplement; one in the director's office is on throughout work hours.

End Bay propane fired radiant: Set to 65 and back to 55 from 2:00PM to 6:00AM
(week: 40 hours at 65 and 128 hours at 55)

The thermostat programming may be responsible for fuel reductions between 8 and 15% of what they would be without nighttime set backs.

Other Electrical Equipment

The office is equipped with standard office equipment: computers, printers, fax machine, copier, (2) coffee makers, (2) toasters, electric can opener, refrigerator, phone charger and Sharp microwave. There is an exhaust fan in the bathroom.

Turner Report Recommendations Summary
Recommendations include: Replace shingles and install ice and water shield; apply preservative coating to siding; consult with plumber on slow draining sink.

More directly related energy recommendations include:
1. Add insulation to the attic and add insulation over overhead door.
2. Install new furnace and upgrade heating system.
3. Install drainage pipe at rear of building under a 2-foot wide apron of crushed stone.

SEEDS' Recommendations
The recommendations below are offered as effective ways to reduce heat loss while improving comfort and air quality, and reducing the risk of condensation on the walls, which always exists in airy and interior insulated metal buildings. Making these investments on a lightly structured building without an insulated slab and which may still have drainage issues is somewhat questionable. Further, it would be prudent to check with a structural expert before any ceiling or roof insulation as snow loads may well increase with a tighter and more effectively insulated building. All that said, the building appears to adequately meet the space needs of the Recreation Department and with effective upgrades, could continue to serve the town for 50 years or more. As always, there is more than one way to make effective energy improvements. The recommendations below have been selected for their 'phasing ability' as that appears to be the most likely funding strategy. It would be prudent to consider a more comprehensive approach should a large lump sum of funds be available.

1. Caulk and weather-strip garage door, windows, and exterior doors.
Estimated cost: $250

2. Remove middle section door and interior metal surface and frame wall with 2x4's offset from metal exterior by 2". Frame for a large door (40" wide min) and window opening. Spray closed cell urethane foam as an even 3" layer, 2" being continuous behind the foam. Install an insulated door and operable window with minimum R3 values, low SHGC, and install with advanced flashing and air sealing techniques. Also remove rear wall metal and spray 3" directly on metal. Cover all with sheet rock or re-install metal.
Estimated Cost: $3,100

*3. Remove all fiberglass in ceiling and spray closed cell foam to a minimum 4" depth. Foam will need to be covered with a 15 minute flame barrier – be it drywall or intumescent paint – or other. Estimated cost: $3,700

*Alternately, for recommendations #3 and #5 : Remove roof shingles on older sections of building and install 6" XPS nail base Foard Foam panels to roof sheathing before re-roofing.

Estimated additional expense over re-roofing: $10,000

4. Remove all fiberglass in walls above office ceiling. Spray 3" closed cell foam directly onto metal siding. Use spray foam to air seal the wall which separates the office and middle sections. Code may permit this foam application to remain uncovered.

Estimated cost: $900

5. Spray a skim 1-2" coat of closed cell foam on wire mesh over office ceiling. More would be preferable for insulation, but this is a compromised suggestion based on the relative improvement vs cost of removing the mesh and existing insulation. The primary goal here is to create an effective air barrier, vapor barrier, and tie both to the wall insulation.

Estimated cost: $900

Energy savings anticipated from recommendations #1-#5 300-400 gallons and reduced or eliminated need for 1 or 2 electric space heaters.
Anticipated $ savings at $2.59/gallon: $850-1150/ yr

6. Remove fiberglass in garage section and spray 4" foam as described in #3.

Estimated cost: $4,000

7. Remove drywall and spray 3" SPF on walls; re sheet rock.

Estimated cost: $2,800

8. Insulate slab floor with 2" XPS at office and middle sections. Cost estimate is for insulation and flooring only – does not include disruption.

Estimated cost: $3,000

9. At this point, only the office walls and garage door will remain in the current existing condition. Upgrading these remaining envelope would result in a building with approximate 75% heat load reduction over the current load. With an efficient heating system, the building should be able to be heated very comfortably with less than 300 gallons of propane and no supplemental electric heat.

Estimated cost: $4,100

Additional savings anticipated after items #6-#9 Another 300-400 gallons and $850-1150/yr

Equipment Recommendations

1. Replace furnace with properly sized (following heat load calculation of improved building) sealed combustion, modulating, high efficiency condensing boiler with air handler. Close and seal door from boiler room to garage and further sever the air connection between the two building areas. As the building is made tighter, it is important to continue to check that there is adequate combustion air for the existing furnace. Replacement can occur at any time, as long as it is not oversized for anticipated envelope upgrades. Replacing it after envelope upgrades 1-5 is recommended.

Estimated cost: $3,500

2. Low energy buildings are tight enough to require mechanical ventilation to provide adequate fresh air for indoor health. While it often sounds counter productive – to tighten a building to the point you have to provide mechanical ventilation – with heat recovery, the energy penalty is minimal and far, far less than allowing for uncontrolled air infiltration. In addition, continuous controlled ventilation assures healthier indoor air than the sporadic nature of uncontrolled infiltration which wastes heat without necessarily improving air.

As improvements are made in the order listed above, there will come a time when mechanical ventilation will be required. Blower door testing at various tightening stages will determine the need. At that time, installing balanced mechanical ventilation with heat recovery is recommended.

Recreation Department

Rink House

Building Description and Energy Consumption

The Rink Warming House and Concession Stand, or Youth Center, includes a 30' x 24' concrete block building which was added to by a 24' x 24' framed structure with 4x4 posts and 2x4 infill studs. A low pitched shed roof covers both structures, as well as a 14' x 24' open pavilion area to the east. The building was recently covered with a standing seam metal roof. The building is on a slab on ground, with the north and west sides paved right to the edge of the slab.

The block house serves as a warming house and concession stand for the rink and has two ADA accessible bathrooms. The "rink" is an asphalt black top with a surrounding curb which is flooded in the winter time for ice skating. Twelve flood lights light the rink. The frame building serves as an after school youth center. The rink is open after school and on weekends in the winter and the rec room is open after school. The door to the framed section is closed when the rec center is closed. The door is not insulated nor forms an air barrier.

Total building energy is not known as it appears there is one meter for the entire Recreation Department Campus. Annual propane use averages 687 gallons for space heating and a cooking grill or 47.7KBtu per sq ft. An Empire wall vented propane heater heats the block warming room and kitchen concession stand.

Air Exchange

Estimated annual air exchange is .5 times per hour and .9 times an hour in the winter. Air leaks are most prominent at doors, exhaust vent openings, a hole in the wall in the kitchen, and where the walls meet the walls. Detailed blower door test results can be found in the visual report.

Envelope Assessment

The ceiling over the block building has an unknown amount of insulation, with thermal bridging through the framing. The block is neither insulated nor covered. The ceiling and walls of the framed section appear insulated, presumably with 3.5" batts in the walls and probably in the ceiling as well. The roof overhang extends over 12" on the north and south and the east wall is covered by the pavilion. Overhangs protect two speakers facing towards the rink.

Heating and Ventilation

During the summer, the building is used 9:00-3:00 during the week and 9:00-3:00 on weekends. Interviews with staff indicated the following: The Empire thermostat is set to 60 degrees for 78% of the week hours except for when the building is open:
Sunday 1:00-6:00 PM
M-Th: 3:00-7:00
Fri, Sat: 1:00-9:00
For those 37 hours, the thermostat is set to 65 degrees.
The electric heater is turned on when kids are in that room.

Additional space heating is provided by a wall mounted electric heater in the framed section.
Other Electric Loads
Other electric equipment includes desktop computers and monitors, two TV's, two exhaust fans (bath and grill), an old Gibson freezer, a Pepsi Cooler refrigerator, popcorn maker, small refrigerator, a microwave, and (14) 4 foot, two tube T12 fluorescent fixtures.

The Turner Report Recommendations Summary
Recommendations were to upgrade the vent hood over the grill and add grab bars in the bathrooms.

SEEDS' Recommendations

1. Weather-strip and seal all three exterior doors.
2. Seal up hole in wall in kitchen near the door.
3. Clean and repair the vent damper for the grill exhaust fan.

Estimated costs: $140

Anticipated savings are estimated at a minimum of 45 gallons of propane or $120 the first year.

4. Replace all T-12 lamp fixtures with T-8's or better. Contact PSNH for any available funds for the conversion.

Estimated cost: $540

Savings will be dependant on use, but could be expected to be paid pack within three to four years.

5. Monitor electrical use of appliances in kitchen and rec room with a Watts Up Meter. Perhaps let the kids track electrical use on each appliance for one week and set up a chart on the computer to report. Of special interest is the freezer, the wall mounted electrical heater, and the power strip for the computers referred to as "phantom loads". Ask the kids to calculate the savings from turning off the power strip when the building is closed and even replacing some of the appliances with new Energy Star rated replacements.

Cost: $79

Phase II
6. Excavate (and hand dig) around the foundation to footing if prudent. Apply a water barrier membrane and insulate slab edge and below to R10. Tuff and Dri / Warm N Dri system is recommended. Install a French drain pipe wrapped in cloth and fill the trench with washed stone.

Estimated cost: $350 plus excavation

Insulate the exterior walls with 4" Nail Base Foard Foam XPS panels and seal to top of Warm N Dri. Remove soffit and extend up just above top plate and foam seal to bottom of propa vents if they exist. Rip soffit and replace. Other detailing needs to keep in mind the goal of establish a continuous air and insulation barrier. Block walls will become effective R21 and the framed section a possible R28.

Estimated cost: $9,800

It is expected that the door is opened frequently during the 37 hours the building is open. However the building is closed the remaining 131 hours where heat loss will be kept to a minimum. The thermostat may be able to be set back to 55 or even 50 degrees without negative consequence. Heat load with reduced air infiltration and continuously insulated walls will be reduced 50-60% with an estimated reduction of annual fuel use between 400 and 450 gallons.

Approximate annual savings at $2.59 gallon: $1,100
Simple payback of 9.25 years

Recreation Department

Contoocook Beach Concession Stand and Bath House

The Beach is primarily used in the summer, with occasional fall use requiring additional heat so the building envelope was not assessed.

Electrical consumption is 5728kWh a year for a cost of $1,070.
Propane use is 118 gallons for a projected cost next year $295.

There are four exterior security lights, three of which appear to run on a timer while the one facing the parking lot has a motion sensor. One of the shaded north facing lights was on at 10:30am. The timer may need adjustment or repair.

Replace five T12 fixtures with T8's or other efficient fixture.

The visual report depicts equipment. It is recommended that a Watts Up Meter or Kill-a-Watt meter be used to measure appliance electricity draws to determine if it would be cost effective to replace with newer, more efficient equipment.

Of particular interest is the refrigeration equipment. The Pepsi fridge ran constantly the hour I was on site, and the woman staffing the stand said it runs all day. It is likely it runs all night as well. She confirmed that the glass showcase was not necessary to sell drinks. One of the other refrigerators was broken, so another one was dropped off from the youth center. The doors did not form a seal when closed. The Candy freezer is also old, appears larger than necessary and far less efficient than newer chest style models.

The electric hot water heater appears old and may be very inefficient. A small tankless water heater so close to the sink would be far more efficient and provide completely adequate hot water service with minimal stand by losses. By monitoring plug loads, the return on investment for replacing the electric water will become evident.

Both burners of the 200,000Btu grill is on every day from 10:30 to 3:00 and is evidently used fairly consistently between 11:30 and 2:00 on a busy day. But only half the surface is used. When they only turned one grill on, there was some kind of 'gunk build up' problem so they have since turned on both sides. Finding another solution to the gunk, or a 50% smaller grill would presumably reduce the propane consumption in half. Three electric fans are used when the building gets too hot.

For example a 15"x24", Star Max Grill uses 40,000Btu and costs $689. It could save 65 gallons a propane each year saving $155 and pay for itself in 5 years. It would create less grease for the non existing vent hood to deal with and reduce the summer heating load by 160,000 Btu/hr for the people who work in the building, either reducing the amount of electric fan time or at least keeping them from overheating.

Transfer Station

Old Sharon Road
Energy Assessment

Building Description, Energy Consumption, and Load Assessments

Transfer and Recycling Centers throughout NH are typically fairly open, pieced together construction techniques, un insulated or super under insulated. Some, though not all, are at least partially heated around the clock even though they are only used fewer than 20% of the hours in a week. Often there is a separately heated space for bathroom facilities for staff. Even if heated, the space is still performs like an outdoor warehouse. The heating is mostly for some degree of worker comfort, since the public comes dressed for the weather and only stays a few moments.

Jaffrey's transfer station is no exception. The warehouse is an open, uninsulated 4000 square foot (40' x 100') metal building. There are two propane fired radiant heating tubes located over the two work stations (glass drop off and sort and paper/cardboard drop off and compacting). The stations are located near a large open doorway for the public to enter with their recyclables. The heaters are either on or off, running on timers which can be set from 2-6 hours. They are typically on 5 days a week, 8 hours a day. Propane use averages just under 900 gallons a year and about $2,000 at last year's prices. Based on the entire warehouse, that equates to about 20.5KBtu per square feet for 1000 heating hours. However, the radiant heaters in this situation primarily effect between approximately 400-600 sq ft of space which translates to over 164KBtu's per square foot – for those 1000 heating hours.

At the other end of the building, and near another large open doorway, are two small, partially insulated, shed type buildings. One serves as an office and warming hut and the other a bathroom with food preparing appliances. Outside, on the other side of the office wall, is a small shed, called 'the shack' located next to a dumpster. All three of these sheds are heated with electric resistance heat.

The office has a 6' electric baseboard and is set on med or high throughout the heating season. On the day of the site visit, the slab floor was 60ºand the ceiling 73º. The bathroom's electric wall heater is also thermostatically controlled and not adjusted. The median temperature was 78º. The toilet is an electric and vented 'Incinolet' and is plugged in 24/7. The shack's electric floor heater is turned on whenever someone is sitting there.

Electric consumption from June '09 through May '10 was 20,720kWh for a dollar cost of $3,910. Use is May, June, July, and August was 780, 780, 700, 780, respectively. It can therefore be deduced that electricity for lights and special recycling equipment on non holiday months is 780kwh and an average $156 for a total annual consumption of 9,360kWh and $1,875.

Use during the other 8 months totals ranged from 1,040 to 2,940 with the peak months in December, January, and February. The total electrical consumption for heating is an estimated 11,360kWh and $2,035. Electric resistance heat is near 100% efficient so it can be estimated that the three shed buildings required 38,760,320 Btu's of heat or 150.2 Btu's (and $7.89) per square foot.

In summary, heating less than 600 sq ft of un insulated warehouse and a total of 258 sq ft in three separate, partially insulated, sheds is arguably the most inefficient building heating system in all of the Jaffrey's Municipal building inventory. At the same time, it has the lowest dollar cost of all occupied buildings.

A "fifth" building in the complex is the swap shop. It has a pellet boiler, electric heater, and lights, but the Town of Jaffrey is not responsible for its expenses or management, so it is not included in this report.

Air Exchange

Blower Door Testing was not conducted. It can be assumed that there is a very high light level of air exchange and since heating is so sporadic, exact measurement would have no or little value.

Turner Report Recommendations

Energy related recommendations include:

1. Investigate the feasibility of adding roof and wall insulation.
2. Cost existing roof and budget for replacement to happen between 2014-2016.
3. Replace inefficient incandescent lamps with energy efficient fixtures.

Recommendations

1. Plug in a Watts Up or Kill a Watt meter into the Incinolet toilet. The website indicated that the unit "Uses about 1 ½ kilowatt of electricity per cycle. Electricity drawn only when toilet is in use." Elsewhere, it also states "Electricity may be needed all the time, even during off seasons, to operate evaporation fan and heater."
Since there are viable and proven low energy composting toilets available on the market, determining the exact energy demand of this appliance is recommended.

2. Connect E-Monitor (recommended Town equipment purchase) to electric panels for two full months to assess base circuit loads. Loads can be evaluated yearly to determine if there are any changes as compared to base anyway. Additionally, lighting loads can be accurately measured.

Cost:: $900

3. As per Turner Report recommendations: "Replace inefficient incandescent lamp holders with 100 watt flood type lamps with low-temperature ballasted T5 high output fluorescent fixtures to improve lighting levels and reduce energy costs." Savings potential can be assessed following the E-Monitor

Estimated Cost: $4,000

4. Frame in two smaller door entrances for the public to use to drop off recyclables. Install 'refrigeration strips' over these smaller (3' x 7') doorways.

Estimated Cost: $300

5. Construct a 12 x 12 super insulated shed to replace existing three small sheds. Position in the corner roughly where the existing office shed is, with it protruding three feet outside the plane of the metal building, in order to be able to have visual access to the dumpster and parking lot and a door to quickly assist people in need. The incinolet, or other, would occupy a small WC in the inside corner adjacent to the exterior wall. Three windows and two doors would provide equal or better visual and physical access that exists now and there would still be as much room for desks, chairs, food prep area, and office equipment.

Construction could be based on a double 2x4 wall, offset with a two inch gap in the middle for continuous insulation, for a 9" cavity and 2x6 ceiling joists and rafters for the exterior shed protrusion. Dense pack cellulose in the 9" wall cavities would create an effective R33 wall with minimal thermal bridging and settled 16" (R60) cellulose on the ceiling. Existing windows could be re-used with the addition of interior therma pane air sealed storms for winter use. Existing doors could be retrofitted with rigid foam and reused.
New materials include framing lumber; sheathing; sheetrock; siding; roofing materials; foam sealants and caulking; cellulose; and other miscellaneous materials. A preliminary design estimates materials would cost less than $4,000.

This same design estimates a total winter heating load at under 5MMBtu, less than 3% of the sum total heat load of the current three sheds. In other words, a 97% reduction in heat load. Internal heat gains from computers, people, Incinolet, and solar heat gain through southern glazing would provide a sizeable offset to heat losses. An efficient electric space heater could act as a back up, though it is estimated that the building would not drop below 40 degrees throughout the winter. Another heating option would be a flat plate solar collector mounted on the south side for an additional investment of approximately $1,000. These devices are projected to provide up to 10KBtu's hour in full sun which could potentially provide 10MMBtu's worth of heat in a winter season, more than twice that what preliminary designs suggest will be needed. In reality, because of the doors opening and closing throughout the work day, a back up electric heater for very occasional use would be prudent, and yet nighttime heating would still not be necessary. A more detailed design and analysis is beyond the scope of this audit, however, preliminary analysis suggests that at a cost of $10,000, the building would realize a simple payback of five years.

It is further recommended that this project be pursued as a community project, enlisting the support of local building suppliers, high school building and science teachers, and local vendors. With donations and promoted as an educational project built with student helpers, the project could cost far less than $10,000. At $5,000, it would have a three year pay back. More importantly the project could serve as a highly visible demonstration of low energy, near passive, buildings as well as saving the town at least over $15,000 over the next 10 years.

As the most inefficient heating system in the town, it also provides one of the best educational opportunities for more than just achieving energy efficiency improvements, but the promotion of innovative sustainable energy strategies. In fact, if the end goal of designing and construction a near zero energy building were agreed upon, S.E.E.D.S. would offer to use Passive House Modeling Design software to help design the building pro bono.

Estimated cost: $5,000

Phase II Recommendations

Reducing the larger heating load of the warehouse does not present such a cost effective and compelling opportunity. As The Turner Report suggested, insulating the warehouse would likely increase snow loads and so an engineer would need to be called upon for s structural assessment of the roof trusses.

Assuming the roof could handle the additional loads, creating a well insulated (Continuous R30 ceiling and walls) metal structure 40 x100 x 10 feet high designed to conserve energy with low or no risk of condensation and moisture problems, would cost at best $50,000.

There are several ways to accomplish this in accordance with sound building science principles. None of those approaches include fiberglass against metal or without being in direct contact with an air barrier on all six sides. Insulating the walls with fiberglass, or even cellulose, would involve considerable infrastructure, whereas rigid or closed cell spray foam would cost more for the insulation, but less labor and materials for the surrounded surfaces.

Detailing these approaches for this long term project is beyond the scope of this audit, yet can happen if requested. (Please note that there may be other code required costs for such a substantial project which are not included in this energy upgrade estimate).

Preliminary calculations project a reduction of up to 700 gallons per year. This also assumes cooperation from staff and the public and the use of plastic 'refrigeration strips' over the doorway during drop off hours. As such, conventional EE payback scenarios call for using current fuel costs with no projected increases over time, nor interest benefits from those annual savings. Saving $1800 a year would indicate payback in 27.8 years.

Alternately, a thirty year historical analysis of energy costs reveals a very volatile cost roller coaster. By adding together the historic dollar expenditures each year for oil or propane, divided by 30, then calculated the average cost increase over those thirty years in order to create a reality based budget, the increase to use would be 6.8% each year. Below is a chart which demonstrates that analysis tool and its projected 17 year pay back on the same improvements.

	gallons	projected fuel cost	annual savings	simple payback $55,000
1	700	$2.59	$1,813	$53,187
2	700	$2.77	$1,936	$51,251

3	700	$2.95	$2,068	$49,183
4	700	$3.16	$2,209	$46,974
5	700	$3.37	$2,359	$44,615
6	700	$3.60	$2,519	$42,096
7	700	$3.84	$2,690	$39,406
8	700	$4.10	$2,873	$36,532
9	700	$4.38	$3,069	$33,464
10	700	$4.68	$3,277	$30,186
11	700	$5.00	$3,500	$26,686
12	700	$5.34	$3,738	$22,947
13	700	$5.70	$3,993	$18,955
14	700	$6.09	$4,264	$14,691
15	700	$6.51	$4,554	$10,137
16	700	$6.95	$4,864	$5,273
17	700	$7.42	$5,194	$79
18	700	$7.93	$5,548	($5,469)
19	700	$8.46	$5,925	($11,394)
20	700	$9.04	$6,328	($17,722)

Ultimately, no one knows what the cost of energy in any form will be next year much less looking 5, 10, 17, or 27 years out. It is most reasonable to assume it will be more than it is today and arguably much more. It is also reasonable to hope that the true costs of securing and burning fossil fuels will start to factor into the dollar value of fuels and energy in which case the numbers above will be far less than actual costs. Research has already demonstrated that the true cost of gasoline in our cars is over $15/ gallon. With that kind of reality, even conventional energy efficiency financial models would favor deep energy retrofits on all existing buildings.

Waste Water Department

Administration Building (Office and Garage @ 2 Old Sharon Road), Pump Houses, and New Facility

Energy Assessment

Building Description and Energy Consumption

The structure of the approximate 2300 sf building was built in 1986 in two sections (about 35' x 45' and 24' x 28') all of which is concrete masonry block with a brick veneer. The larger section houses an office, boiler room, a maintenance room, and a 10' x 35' attached garage. The smaller section includes a hall, bathroom/locker, and lab. There appears to be rigid insulation between the block and veneer but the thickness is not known. Six casement metal, therm-apane windows and a glass storefront entry account for less than 6% of the wall surface area.

Total building on site energy use is not known because there is only one electric bill for all waste water sites. The building is heated by a new oil boiler and a wall mounted electric heater. Total heating oil fuel energy use averaged 1597 gallons during the two previous years, but used a total of 970 gallons for the '09-'10 year. New equipment, and another building, are presumed at least partially responsible for the reduction. At 979 gallons, (137,000 Btu's) heating fuel energy index is 60.3KBtu/sq ft.

Interviews with staff indicated the following: The building is staffed by two people. Office hours are 7:30-3:30 on weekdays and between three and four hours on the weekends for monitoring or special circumstances. Staff is in and out of the office frequently to monitor well and pump facilities.

Air Exchange

Blower door test results indicate a very leaky building with significant opportunities for air sealing the windows, doors, and ceilings in particular.

Envelope Assessment

The heating equipment is believed to be responsible for approximately 20% of the heating fuel consumed through inefficient combustion and distribution.

The estimated design peak heat load of the existing building is 99.2Kbtu/hr. Envelope Loads represent the remaining 80% of total energy used for heating. Of those approximate 99KBtu's needed on a 0 degree night, or the annual 800-900 gallons:

Convective Losses:	Air infiltration 44%
Conductive Losses:	
CMU walls	30%
Slab	5%
Windows	4%

Garage Doors	3%	
Lab Ceiling	6%	
	Garage/Lab Ceiling	8%

Significant contributors to air leakage are in bold above.

As is often the case, the components of the envelope that represent minimal conductive losses contribute the greatest to air leakage and convective losses. While windows, doors, and the ceiling (in bold) only account for approximately 13% of the total heat loss by conduction, they represent over 90% of the air infiltration and exfiltration in the building, which is the single largest source of heat loss and energy use.

Other Electric Loads

Envelope loads impact electrical use as well as fuel consumption. Electricity for pumps for distributing hot water is directly related to heat loss and gains of a building. In addition, the Waste Water Admin building has a number of electrical appliances and lighting. The office is equipped with standard office equipment: computers, printers, fax machine, copier, coffee makers, refrigerator, and phone charger. There is an exhaust fan in the bathroom, lab and garage. The bathroom has a shower stall which is used infrequently.

Turner Report Recommendations

Recommendations include installing strobes, grab bars in the bathrooms, and re-caulking vertical control joints in the brick façade.

More direct energy related recommendations include:

1. Replace the boiler (this has been done)
2. Insulate all piping in the attic space subject to freezing.

SEEDS' Recommendations

1. Caulk and weather-strip garage door, windows, and exterior doors.

Estimated cost: $225

2. Install removable air sealed therma-pane interior storms on all six windows and permanent air sealed therma-pane interior storm panels on two fixed side lights at entry.

Estimated cost: $1600

3. Remove both louvered vents from former generator room. Frame in 2x6 wall (window in one opening recommended for light) but off set to interior. Install 2" rigid polyiso on outside of studs then cover with sheathing and WRB (weather resistant barrier). Leave air space and side as desired. Foam seal all transitions, net and blow cellulose in cavities. Do not cover with vapor retarding material and drywall.

Estimated cost: $1400

4. Replace all T12 fixtures with T8 or better efficient light fixtures. Replace recessed lights with below ceiling efficient track or other. Replace bathroom exhaust fan and duct to outside with rigid ductwork. Insure that all ceiling fixtures are rated to be sealed and insulated.

Estimated cost: $940

5. Attic over lab, hall and bathroom (675sf): Run new water lines from boiler room to bathroom and lab inside conditioned space, so that no water lines exist in this attic. Establish air barrier above ceiling plane by removing all debris above the ceiling and spraying 2” closed cell foam. (Option 3 in visual report) Spray 4” foam over all perimeter top plates and create a barrier up to soffit venting. Blow in 12” cellulose on top of foam in an even layer. Gasket seal and cover attic hatch with insulated cover.

With all due respect the Turner Report, reducing energy use would promote air sealing and improving insulation at the ceiling plane which would make the attic even colder. With the limited use the building gets now, it is likely then, that almost no amount of insulation would prevent freezing pipes. The conventional next step would be to use electric heat strips around the pipes when insulation failed. Clearly SEEDS’ recommendation involves far more up front costs, but is still offered as the alternative, long term, and ultimately less costly, suggestion.

Estimated cost: $4,400

6. Attic over office and garage: (1575sf) Remove all fiberglass and debris. Build up center walkway 12” above existing decking. Metal flash and caulk with fire stop around chimney. Air seal all penetrations and establish a continuous and effective air and vapor barrier at attic floor plane by spraying a continuous 2” layer of closed cell foam on back of drywall and joists. Blow 12 inches cellulose in even layer. Build a gasket sealed insulated cover for attic hatch.

Estimated cost: $7,510

Equipment Recommendations

7. Install and program programmable thermostat and set back for all nights from 3:00PM to 6:30AM. Set back temperature will vary depending on time of year, conditions, and improvements made. With recommendations 1-6, temperature should be able to be set to 55-58 or lower.

Estimated cost: $85

8. Repair or install dampers for both combustion air make up vent openings and both exhaust fans in garage and lab.

Estimated cost: $95

9 After any and all air sealing, another blower door test should be conducted to determine air tightness and air exchange. Balanced ventilation with energy recovery (ERV) is recommended following effective air sealing if necessary. For between $2-2500K, excellent air exchange can be accomplished with minimal energy penalty.

Estimated cost: $2,500

Estimated benefits from recommendations #1-9:

1. 35% or 350 gallon reduction for an annual savings of an estimated $908 a year for a simple payback of 5.2 years.
2. Reduced carbon emissions over 7800 lbs / year.
3. Improved air quality.

4. Improved comfort year round.
5. Reduced or eliminated ice dams.
6. An estimated new design peak heat load of 56KBtu/hr.

Savings from light replacement will be influenced by occupancy and human behavior but T8's should use 35% less energy than T12's whenever they are on.

Waste Water Pump Stations Recommended Improvements

Without fuel use data, no recommendations have been made. Infra red images are included in the Assessment Part II. Each of the buildings can be better insulated and air sealed, in keeping with the same principles and recommendations throughout this audit, however the anticipated fuel use may not warrant considerable investments. In addition, it was indicated that some of these pump stations are going to be replaced with underground stations which would dramatically reduce heating fuel use.

New Waste Water Facility
4 Old Sharon Road

PSNH sends one bill for Old Sharon Road for "Sewer" under Meter #G10482851. Total KWH consumed from June '09 through May '10 was 482,400 (1,645MMBtu's) or 41% of the town's total demand. At this time, it appears that this includes this facility, the old administration building and all pumping stations. Oil use for the winter of '09-'10 was 2961 gallons or 414,540,000Btu's. When pump station and old admin building heating are included, total "sewer" energy load exceeds two billion Btu's.

Despite the relative proportion of this energy use to the total municipal load, this facility was not part of the S.E.E.D.S proposal for an audit of Jaffrey's Municipal buildings. A walk through was conducted, with the manager and an IR camera. Infra red images were taken on a fairly warm day which depict common heat loss patterns from standard construction practices. They are included in the Waste Water Assessment visual report.

There are two recommendations to the Town:

1. Consult with an electrical efficiency expert on an appropriate monitoring system to be able to spot excessive draws or inefficiency problems quickly.

2. Establish a Town Energy Policy and include the protocol to consult with a High Performance Building or Energy Consultant before and during ALL renovation or new construction projects. A minor increase in construction costs to significantly improve the envelope performance can pay for itself in the first year or two, as opposed to hiring auditor years later to discover how its been operating inefficiently from the beginning and the very costly ways to fix it.

Ultimately, the Energy Code, much less conventional performance factors, is a minimum standard and is far behind what is required for a truly efficient building.

Water Department
Office and Garage

Energy Assessment

Building Description and Energy Consumption

The structure of the 30’ x 74’ building is concrete masonry block with a brick veneer. Half of the building serves as an office and has a small bathroom and kitchenette which also serves as a water testing lab. The other half of the building serves as a 2-3 bay garage.

Total building on site energy use is over 288MMBtu’s or 124.4KBtu/sf. The building is heated by a propane fired hot air furnace and three ceiling mounted Janitrol heaters. Total heating propane fuel energy use averages at 105KBtu/sf.

Interviews with staff indicated the following: The building is staffed by two people. Office hours are 7:30-3:30 on weekdays and between three and four hours on the weekends for monitoring or special circumstances. Staff is in and out of the office frequently to monitor well and pump facilities. The thermostat in the office is set to 68 degrees 24/7. The three garage thermostats are either “off” or set at 68 degrees.

The Water Admin building has used an average of 2549 gallons of propane for space heating for the past three years. Several improvements were made prior to the ‘09-’10 heating season; some based on the findings and recommendations of the Turner Report. These included replacing the front door and adding insulation above the ceiling. In 2008, an electric hot water heater was installed. Propane deliveries for this past heating season totaled 2168 gallons, or 14.9% less than the three year average. It is likely that some of this reduction was the result of changes made, however it should be noted that the sum total of municipal fuel deliveries this past winter were 12% less than the three and four year averages. Based on the findings of this assessment, it is believed that the added insulation and door replacement were not the primary factors in the reduction of heating fuel.

Air Exchange

Whole building blower door test resulted in 7523CFM50 and 18.65ACH. This translates to an estimated air exchange under natural winter conditions of approximately twice an hour. While the overhead doors account for a considerable amount of air infiltration in the garage, the windows, exterior doors, and ceiling are the primary culprits.

Envelope Assessment

The office portion has been framed on the interior with 2x4 metal studs with 3.5” fiberglass batts in the cavities effecting an overall estimated R9 wall assembly – (includes the 8” concrete block). The garage bays walls are not insulated and are estimated as an overall R2. There are three exterior doors and three garage bay doors, for a total door surface area of 390 sf or 12% of total wall surface area. Thirteen double paned, vinyl windows create a total glazing surface area of 118sf or less than 4% of total wall surface area. The remaining net wall surface area is divided almost equally between the CMU block and the interior framed portion; approximately 1360 sf each.

The roof is a cold, vented, gable style truss frame. A suspended ceiling hangs from 2x6 truss joists at 24'OC. These joists are strapped and partially lined from below with a hole riddled layer of vapor retarding polyethylene. Two layers of various thicknesses of fiberglass batts lay on top of the strapping. There is no air barrier and no continuous surface over the office, though the ceiling over the garage is covered in sheetrock. Flexible heating ducts for the office are in the chase between the suspended ceiling and the strapping above.
The following analysis is based on the results of the site visit, infra red imaging, blower door testing, spreadsheet heat loads and bin data analysis.

The heating equipment is believed to be responsible for approximately 20% of the heating fuel consumed through inefficient combustion and distribution.

Envelope Loads represent the remaining 80% of total energy used for heating. Of those approximate 2000 gallons:

Convective Losses:		Air infiltration	34%
Conductive Losses:			
CMU walls	33%		
Slab	17%		
		Framed Walls	7%
Windows	3%		
Garage Doors	3%		
Ceiling	2%		

As is often the case, the components of the envelope that represent minimal conductive losses contribute the greatest to air leakage and convective losses. While windows, doors, and the ceiling (in bold) only account for approximately 9% of the total heat loss by conduction, they represent over 90% of the air infiltration and exfiltration in the building, which is the single largest source of heat loss and energy use.
Significant contributors to air leakage are in bold above.

Other Electric Loads
The office is equipped with standard office equipment: computers, printers, fax machine, copier, (2) coffee makers, (2) toasters, electric can opener, refrigerator, phone charger and Sharp microwave. There is an exhaust fan in the bathroom, kitchen, and garage. The bathroom has a shower stall which is used infrequently.

Envelope loads impact electrical use as well as fuel consumption. Electricity for cooling, pumps for distributing hot water, and blower fans, is directly related to heat loss and gains of a building. In addition, the Water Admin building has a number of electrical appliances and lighting.

The recommendations below are offered as effective ways to reduce heat loss while improving comfort and air quality, and reducing the risk of condensation on the walls, which always exists in airy and interior insulated metal buildings. Further, it would be prudent to check with a structural expert before any ceiling or roof insulation as snow loads may well increase with a tighter and more effectively insulated building.

Turner Report Recommendations
Recommendations include: Securing the electrical disconnect; painting doors; secure vinyl; upgrade office finishes, such as carpeting, ceiling tiles, and paint walls; install a fire alarm system.

More direct energy related recommendations include:
1. Replace front door with insulated metal or fiberglass door
2. Remove excess vegetation away from edge of building
3. Remove old mulch and topsoil to lower grade and expose weep holes
4. Remove a strip of pavement along the front and install drip edge
5. Replace weather-stripping and caulking as required
6. Upgrade the ceiling insulation
9. Install a new high-efficiency hot air furnace.

SEED's Recommendations
1. Caulk and weather-strip garage doors, windows, and exterior doors; including the front door which was recently installed. (#5)

Estimated cost: $850

2. Establish air barrier at attic floor plane. (#6) There are several ways to do this but the recommended option is to remove the fiberglass and install a ¾" plywood floor deck. Care will be needed where the plywood meets the trusses to create a continuous air barrier. A center walkway can be installed, built up to a height which allows an adequate insulation cavity. Metal flash chimney and all flues, then caulk with fire stop. Air seal all remaining penetrations including (enlarged) attic hatch. Foam seal a minimum of 2" closed cell SPF over all top plates, up to an installed rigid air chase (as opposed to propa vent). Sixteen inch blown cellulose in an even layer is the preferred insulation and included in the estimated cost. But fiberglass batts can be put down again, criss crossing layers and fitting as tightly and evenly as possible. Install insulated box over hatch.

Estimated cost: $6,000

Equipment Recommendations
3. Replace furnace with properly sized (following heat load calculation of improved building) sealed combustion, high efficiency condensing boiler with air handler. (#9) Close and seal door from boiler room to garage and further sever the air connection between the two building areas.

4. Install and program programmable thermostat for all nights from 3:00PM to 7:00AM. Set back temperature will vary depending on time of year, conditions, and improvements made. With recommendations 1-3, temperature should be able to be set to 55-58 or lower. After insulating exterior walls, temp should be able to be set back to 50 degrees or lower.

Rough Estimated equipment cost: $10,300

Estimated benefits from recommendations #1-4:

1. 33% or 800 gallon reduction for an annual savings of an estimated $2000 a year for a simple payback of 5.2 years.
2. Reduced carbon emissions 9800 lbs / year.
3. Improved air quality.
4. Improved comfort year round.
5. Reduced or eliminated ice dams.

Phase II - Deeper Energy Retrofit

5. For deeper energy savings, insulate the exterior of the building with R20 continuous rigid foam for an effective R value of R30 on the office and R22 on the garage. There are several ways this can be done. The strategy which has been roughly estimated is to use 4" XPS Foard Foam panels and replace the exterior finish. Exterior insulation effectively warms the wall to reduce risk of condensation from vapor and allows for a complete air sealed and insulated enclosure.

The Water Admin building is a good candidate in that it is a simple shape with minimal window and door openings in the walls. It would be essential to either remove the brick façade or effectively seal it at the top and bottom to eliminate contact with outside air. Roof rakes would be needed on the gable ends, but overhangs allow for added wall thickness without blocking soffits.

Replacing the windows makes most sense during an exterior retrofit. Good quality, tight windows with a minimum R3.5 is recommended at this time.

Items #2-4 would be especially important

Rough Estimated Costs: $47,500

Insulating the walls, in addition to improvements above, would

1. Reduce the Design Heat Load (and equipment size) to under 45KBtu/hr
2. Annual propane use less than 700-800 gallons (<1000 gallon /yr reduction)
3. Additional CO emissions reduction of 10,200 lbs / year
4. Additional savings of $2500 for an oversimplified payback of 19 years

6. After any and all air sealing, another blower door test should be conducted to determine air tightness and air exchange. Balanced ventilation with heat recovery is recommended following effective air sealing. For between $2-2500K, excellent air exchange can be accomplished with minimal energy penalty.

Electrical Recommendations

4. Purchase a Watts Up Meter and monitor all appliance use. Refrigerators especially can add significant draws on electricity. Older, donated appliances, can seem like a wind fall, but can add significantly to the energy bill. Replace appliances with Energy Star qualified at a minimum.

5. Unplug the water cooler. It is rarely used and a constant draw.

6. Connect appropriate plug in loads (not servers, message machines, or emergency equipment) to power strips which can be turned off at night and when not in use. “Phantom Loads” can add up to a significant electrical draw over time. Use Watts Up Meter for a few days per power strip and track what could be saved if turned off the 72% of a week’s hours the building is unoccupied.

Water Supply Wells and Pump Stations Recommended Improvements

Bullet and Poole Tanks

1. Remove both Patton electric heaters and keep one in the truck in the event a long service call is required.

   Cost: $0

   Savings: 7629 KWH's

   Dollars: Unknown (service still required)

Contoocook Well on Woodbound

2. Install data logging monitors to track electrical use, by circuit is best.

Estimated Cost: $900

Savings: Informational for to reduce risk of significant pump or motor inefficiencies

3. Long term – Wrap exterior of building, walls and roof, with 4-6" XPS Foard Panels and side with fiber cement board – or veneer block for damage control. Would require roof extensions.

   Rough Estimated Cost: $8.50/sf to install panels and $4/sf for siding =

   Cost: $21,625

   Savings: Estimated 5-600 gallons within a simple payback of 10 years when propane reaches $4.00 gallon.

Turnpike Well

4. Monitor with data logging equipment   Cost: Use above equipment

Main/Prospect/124W

5. Weatherstrip doors
6. Air Seal ceiling and add insulation to R50

   Estimated Cost: $2,400

   Estimated savings: 100-120 gallons

   $285 year; 8.4 year payback