ARCHITECTURAL CONSULTING ENGINEERS

HVAC □ Historic Buildings □ GSHP □ Sustainable Design

March 5, 2014

Mechanical System Assessment & Feasibility Study – Keokuk Union Depot

Existing Conditions

The Keokuk Union Depot building is a masonry building with single glazed windows, uninsulated masonry walls, and minimally or uninsulated roof/attic space. The building is generally a single-story structure without a basement however there is a second story above the Baggage Room which was originally used for residential purposes as well as an office which looked out over the train tracks. A Boiler Room sits at the far end of the structure with a tall chimney that served the original boiler which was almost certainly fired by coal. Tall chimneys were required to induce the proper draft for the combustion of the coal. These chimneys are signature architectural features to buildings of this time. There is no coal storage room within the building so the coal may have been stored in a local support structure that is no longer standing, remained on a coal transport rail car, or was simply stored on the ground near the building. Coal needed for daily use was most likely brought in by hand cart and stored within the boiler room.

There is a shallow utility tunnel that extends from the boiler room along the foundation of the building on the river side (plan south). This tunnel was used to route steam, condensate and domestic plumbing piping throughout the building. Much of this piping is still located in this tunnel, although the steam and condensate piping is abandoned in place.

The building consists of multiple spaces including a large Waiting Room, Baggage Room, Mail & Freight Rooms, Boiler Room all on the first floor and an Office, Bunk House & Bathroom on the second floor. The Boiler Room does not have a suspended ceiling and sits below the high vaulted ceiling space. This vaulted space allows for direct access from the Boiler Room into the attic above the adjacent Freight Rooms. The Waiting Room is a large volume space under a vaulted ceiling. Men's and Women's bathrooms and the Ticket Office are also contained under this vaulted roof structure, each with a ceiling structure that creates a platform above.

The boiler and most of the radiators have been removed from the building. Some radiators are still connected into the below grade piping and others appear to be stored and are not connected into the abandoned piping system. There are a variety of radiator styles evident in the building, but it is not clear what was the dominant style originally installed. It is quite possible that radiators were replaced throughout the years or salvaged radiators from other buildings are being stored at this building in anticipation of their possible use.

The building is only partially heated at this time. The Waiting Room is served by a horizontal high efficient gas-fired furnace and remote condensing unit which is installed on the platform above the restrooms. Air devices are located at the perimeter of the elevated platform to distribute air to the space. The furnace flue and combustion air piping is connected to a concentric fitting installed in the roof dormer immediately adjacent. The unit is a Carrier Model 59TP5A120E241122 and is rated for 120 MBH heating input. The condensing unit is located at grade nearby on the plan north side of the building and is a Carrier Model 24ABB036A0032010, rated for 3-tons cooling capacity. This system is reasonably new and in good shape however given it was unable to maintain temperature within the Waiting Room on the day of our survey when the outside temperature was at about 0°F it is obvious that the system is

Architectural Consulting Engineers
837 Hayes Avenue,
Oak Park, Illinois, 60302

Office: (708) 524-0272
Email: menussbaum@comcast.net
Web: www.ace-oakpark.com

undersized for the required capacity. The Baggage Room, which is currently used in part as a wood working workshop where sanding and finishing occurs, is conditioned with a standard efficiency vertical flow gas-fired furnace rated for 75 MBH input which vents through a temporary wood infill transom opening. The system is older but given its temporary style installation, it is adequate for the current use. A window air conditioner is also installed in this transom for cooling. The balance of the building is unconditioned. ***We would note that with the wood sanding and finishing that occurs in this room, the open combustion furnace is probably not the best choice for heating the room as it presents a small, but real fire hazard for the space and occupants.***

Functioning plumbing for the building consists of the Men's and Women's rooms in the Waiting Room. Hot water for these rooms is provided by a small electric 6-gallon, 2 KW, tank style heater (Rheem Model 81VP6S) located on the platform above the restrooms. Domestic water piping is generally routed exposed within the restrooms. Sanitary waste is connected to the existing below grade sanitary sewer while vent piping is extended surface mounted up through the roof. The main water service comes into the building in the plan SE corner of the Baggage Room and is extended through the tunnel to the restroom. We did note during our survey that there is small leak in the cold water distribution piping. A second electric tank water heater is located below the stairs to the second level. There is a defunct bathroom on the second floor that consisted of a toilet, sink and shower. This area is unheated so these fixtures have been taken out of service. Similarly a kitchen style sink located in the Bunk Room on the second floor has been removed from service. Storm drainage from roof drains is located around the building. Drains are extended to grade on the plan north side but are directed below grade to an unknown termination point on the plan south side of the building.

The building is served by an overhead, 200 Amp, 240 Volt, 1 Phase electric service entering into the Baggage Room on the plan north side from a pole mounted transformer. The service is then broken up into two metered services within the building – two, 200 Amp distribution panels served by 100 Amp circuit breakers in the main panel and a third smaller panel. It appears that the original electrical distribution is largely, if not completely abandoned, with a newer surface conduit system installed in its place with the possible exception of the Waiting Room where the conduit and conductor is concealed. Lighting in the Waiting Room is provided by up-light spots located on the platforms above the restrooms and ticket office. Exit lights for this room are temporarily wired with extension cords from receptacles in the restrooms.

Load & Energy Study - Envelope

As part of this report, we have evaluated the building and our understanding of the planned future uses of the building, to develop a HVAC load and energy use study to assist in determining the type and size of any future new HVAC system that might be installed in this building. Initially we have modeled the building envelope as it currently exists with the new functions and occupancies to determine what the system size would be without fundamentally changing anything on the building.

We have assumed the following envelope conditions and occupancies for this study:

- Brick (8") walls – no insulation
- Single-pane windows – standard glass
- Waiting Room to be used as Assembly Occupancy
- Remainder of the building to have an Office/Business Occupancy – This is a conservative assumption since some areas will be used for storage and utility, but in general there is a low ventilation requirement for this occupancy so we feel at this point it is a reasonable assumption to

make to ensure for flexible design of the space uses

- Mechanical ventilation assumed in all areas as required by code

The results of this study show that the existing envelope has very poor thermal performance due to the lack of insulation and window improvements. With the proposed occupancy and ventilation included, the existing building requires over 36-tons of cooling and 550,000 Btuh of heating capacity. The load for the building envelope is about 80% of the total cooling load and 90% of the total heating load for the building. Due to the high envelope loads, the ventilation load as a percentage is quite low even in the assembly spaces. For a building of this size and occupancy this is grossly out of proportion to what it would be with even modest envelope improvements.

Based on the above, the resulting heating and cooling loads for the existing building without envelope improvements are as follows:

- Waiting Room (Assembly Occupancy)
  - 19.4-tons Cooling Load
    - 13.8-tons envelope load
    - 3.9-tons internal loads (lights & people)
    - 1.7-tons ventilation (Energy Recovery Ventilator (ERV) assumed)
  - 276,000 Btuh Heating Load
    - 257,000 Btuh envelope load
    - 19,000 Btuh ventilation load (ERV assumed)
- Balance of building (Office/Business Occupancy)
  - 18.1-tons Cooling Load
    - 13.0-tons envelope load
    - 3.8-tons internal loads (lights & people)
    - 1.3-tons ventilation (Energy Recovery Ventilator (ERV) assumed)
  - 271,000 Btuh Heating Load
    - 238,000 Btuh envelope load
    - 34,000 Btuh ventilation load (ERV assumed)

In order to assess how the building performs thermally, we have also modeled the building with general envelope improvements. This allows us to see the impact on HVAC system size and operating expense by making passive envelope changes. We generally recommend making whatever reasonable envelope improvements can be made since this usually results not only in passive measures with long term energy savings but also in upfront cost savings for equipment. Envelope improvements also often result in a more comfortable space for occupants.

Given the historic nature of the Waiting Room area with exposed brick walls, beautiful windows and vaulted wood ceiling, options for improvements become limited. The exposed face brick walls cannot be insulated without destroying their contribution to the space aesthetic. The beautiful vaulted ceiling can similarly not be insulated on the interior, but since there is a future project to restructure and re-roof the building, an opportunity to apply a rigid foam insulation board above the roof decking but below the shingles is available and should result in dramatic improvement.

Other areas of the building can easily be adapted with improved roof insulation but the exterior walls are also exposed brick without insulation so a decision would have to be made whether to cover this brick with an interior insulated wall or leave these walls as originally built. Since these spaces are likely to adaptively reused, it is reasonable to assume an insulated wall on the interior would not present an aesthetic issue. The common demising walls could still be left as exposed brick if desired.

Mechanical System Assessment & Feasibility Study – Keokuk Union Depot

Windows throughout the building are single-pane. It is possible to modify these windows with thermal insulated glass but our concern would be the dramatic alteration of how the building looks. A storm window option can provide many of the benefits of the thermally insulated replacement glass with direct modification to the window frames. Since window load for heating and cooling represents a high percentage of the total building load, we recommend that wooden storm windows be custom produced for all windows in the building.

We have assumed the following envelope improvements and occupancies for the purposes of this study:

- Brick (8") walls – no insulation in the Waiting Room
- Brick (8") walls – R-19 insulation from interior furred out walls in the balance of the building
- Single-pane windows – standard glass, with new wooden storm windows throughout
- Improved infiltration control through weather stripping and sealants, door sweeps
- Two inch exterior poly-iso roof insulation in the Waiting Room area – applied during re-roofing.
- Code compliant roof insulation (R-38) applied at the underside of the roof deck in the balance of the building which is served by an attic
- Waiting Room to be used as Assembly Occupancy
- Remainder of the building to have an Office/Business Occupancy – This is a conservative assumption since some areas will be used for storage and utility, but in general there is a low ventilation requirement for this occupancy so we feel at this point it is a reasonable assumption to make to ensure for flexible design of the space uses
- Mechanical ventilation assumed in all areas as required by code

The results of this study show that the improved envelope has very good thermal performance especially when compared to the existing structure. With the proposed occupancy and ventilation included, the improved building requires about 22-tons of cooling and 290,000 Btuh of heating capacity representing a 40% and 48% reduction in cooling and heating respectively. The load for the building envelope is now about 65% of the total cooling load and 75% of the total heating load for the building which is much better than the unimproved existing structure.

Based on the above, the resulting heating and cooling loads are as follows:

- Waiting Room (Assembly Occupancy)
    - 11.6-tons Cooling Load
        - 6.0-tons envelope load
        - 3.9-tons internal loads (lights & people)
        - 1.7-tons ventilation (Energy Recovery Ventilator (ERV) assumed)
    - 140,000 Btuh Heating Load
        - 121,000 Btuh envelope load
        - 19,000 Btuh ventilation load (ERV assumed)
- Balance of building (Office/Business Occupancy)
    - 10.6-tons Cooling Load
        - 6.0-tons envelope load
        - 3.9-tons internal loads (lights & people)
        - 1.7-tons ventilation (Energy Recovery Ventilator (ERV) assumed)
    - 147,000 Btuh Heating Load
        - 99,000 Btuh envelope load
        - 34,000 Btuh ventilation load (ERV assumed)
        - 14,000 Btuh Other load

Proposed MEP Improvements

In order to evaluate how these two envelope conditions consume energy, we modeled two different HVAC system approaches. We consider a system with standard efficiency that has a relatively low installation cost and a more expensive but highly efficient system. The overall effect of the higher efficiency will be reduced operating costs but since there is a higher upfront capital cost associated with these systems careful consideration must be given. The two systems considered are a conventional style system with gas-fired equipment and remote exterior condensing units and a geothermal based system – both to be described in more detail later in the following sections.

Mechanical - Zoning

In both systems explored, one aspect that is universal is a desire for improved zoning. Zoning can be handled in a variety of ways and depending on how it is implemented, zoning always improves the temperature control in the building and often but not always can reduce the operating costs due to reductions in operating system capacity. The simplest form of zoning is done with modular systems. This means multiple small units serving one or more areas. If left at that level of control, the zoning is at the system level and whatever areas are served by a particular HVAC unit are included in that particular system zone. Each system can be further zoned with the addition of other control features, should that zoning be desired.

As of right now, we are recommending primary zone level controls for: 1) Waiting Room; 2) Second Floor; 3) Baggage Room; and 4) Freight/Mail Rooms.

Mechanical – Intermittent Use Accommodation

Given the likely intermittent use of the space, it is anticipated that there will be a need for setback of space temperatures when unoccupied and the capability to recover reasonably quickly for events. The setback temperature control is easily accommodated with the use of properly selected controlling thermostats. These same thermostats should be capable of occupied/unoccupied scheduling as well so that outside air system components can be shutoff when the building is not actively in use to save the operational cost of conditioning fresh. An added benefit of this type of control is that when the building goes into occupied mode, a warm-up/cool-down function can be enabled that continues the disablement of the outside air systems which diverts this system capacity into rapidly recovering the building occupied set points. Additionally, since a high percentage of the building load is due to occupants, lights, and other internal loads, this system capacity is also there to assist in the transition from unoccupied mode into occupied mode.

Mechanical – System & Room Level

<u>Waiting Room:</u>

Without a basement or attic above, there are limited options where new mechanical equipment can be located without creating an aesthetic or noise issue. Additionally, the high ceilings, exposed uninsulated walls, and high proposed assembly occupancy of this space pose especially challenging circumstances for an effective HVAC solution.

Given the limitations of the space (no basement or attic), high ceilings which creates a large air volume, and a lack of wall and limited roof insulation, a radiant floor heating system would be an excellent choice to assist with the base heating load of this space. Radiant systems heat the surfaces that have a direct line of sight with the floor instead of heating the air volume, which will include the ceiling and uninsulated walls, thus creating a much more comfortable space for visitors. Radiant floor systems, while slow to respond to building load changes, are extremely efficient in delivering heat to the space so are an excellent choice to provide the base loading for the space. In the case of the Waiting Room, we would recommend that all air systems be shut off when the building is unoccupied and the radiant system holding temperature be reduced to as low as desired. In a typical historic building we would not normally recommend this level of intervention to an existing flooring surface but since this floor is not historic, there could be the two-fold benefit of installing the radiant system in a new floor that would replicate the historic tile and pattern that was covered over by terrazzo at some point in time.

As noted, in this application however, any floor radiant heating system installed will be inadequate to provide for the full heating load of the space plus it does not take into account the need for outside ventilation for the assembly occupancy. Some type of supplemental system(s) will be required to provide for these requirements. Since hot water would be provided to the space for the radiant flooring system, some of the needed supplemental heat could be provided by the re-introduction of decorative cast iron radiators. These would typically have been installed along the perimeter wall, often near doors or windows. When the radiant floor is installed, investigation could be done to see if remnants of these historic locations exist. Regardless though, reinstalling active decorative radiators to this room would add to the historic ambiance.

A supplemental forced air heating and cooling system, located above the Ticket Office and similar to the existing furnace above the bathrooms would take care of the balance of the required heating load, provide the bulk of the cooling load and provide for reasonable air distribution. We would remove the existing furnace system over the Toilet Rooms to allow for the proposed relocation of these rooms (see other sections of this report). We would however recommend a slightly different detail be implemented at the air devices located around the perimeter of the elevated platform to better conceal them. A lower profile air device that is integrated into an enlarged trim or an ornamental grille would resolve this aesthetic issue and make the system equipment less visible. Since there is no simple way to introduce outside air into this unit and given the large outside air requirement for the assembly occupancy, we recommend that a dedicated outside air system (DOAS) be used to provide pre-conditioned ventilation air to the space. This will provide multiple benefits to the overall system configuration: 1) It will keep the forced air system size smaller on the platform above the Ticket Office thus making it easier to keep concealed; 2) Some of the space cooling load could be handled by this equipment in addition to the ventilation load which will also reduce the size and capacity of the space mounted equipment; 3) It will allow for the use of an Energy Recovery Ventilator (ERV) as part of the DOAS which will save significant operating expense; 4) It provides for a multi-tiered approach to the system operation – radiant floor and cast iron radiator base load (heating only) – forced air (heating and cooling) – dedicated ventilation (heating and cooling) – which will use only enough system capacity to meet the needs of the space at any given time.

The DOAS and ERV are proposed to be located in the attic above the second floor. The interior brick wall between the Waiting Room and the Baggage Room and second floor above does have an existing opening near the peak of the Waiting Room ceiling. We propose that we introduce the conditioned outside air at this central location through a new, enlarged opening and ornamental grille. Relief air from this space could be taken from a new opening located in the new Toilet Room common corridor that is integrated into the existing Baggage Room (see other sections of this report) to allow for the relief air to return to the ERV. Energy from the interior air would be exchanged with the incoming unconditioned outside air saving significant energy (up to 75%) of the cost to condition the OA air stream. Outside and exhaust air intake and relief openings will have to be accommodated from this attic space. If the roof structure is returned to the original form as is proposed, these openings would be easily worked into this plan.

As an additional control and energy saving feature, we recommend the use of Demand Control Ventilation (DCV) in the assembly spaces which allows for the continuous measurement of carbon dioxide (CO2). The function of outside air ventilation is ostensibly to dilute the CO2 in a space. Instead of the standard proscriptive method of assuming a maximum occupancy of people that could be in the space and delivering the code required volume of outside air whenever the space is occupied, we can instead use an objective measurement of CO2 and deliver only enough outside air to provide for proper dilution. This is particularly effective in large volume spaces and where air infiltration or frequent opening of exterior doors provides for the natural ventilation and dilution of this CO2.

Baggage Room:

Similar to the Waiting Room, the Baggage Room does not have either an attic or basement space above or below. There is a second floor space that occupies the full footprint of the Baggage Room, so this space does not have any associated roof load. We are assuming that it will function as either toilet room/common/utility space or office/retail space.

In order to maintain the maximum floor space in this room for the proposed new functions, we recommend that a forced air system (heating and cooling) be installed in the attic above the second floor and a duct chase be developed from the attic, through the second floor, to the ceiling of the Baggage Room. We assume a new ceiling is planned in this room that could be dropped, and the ducts could be completely concealed. Ventilation air for this room would be provided from the same DOAS and ERV system that serves the Waiting Room. Instead of dumping this air directly into the Baggage Room, the air would be directed into the return of the air handling unit up in the attic, thus eliminating the need for additional duct chase space.

Balance of Occupied Areas:

The balance of the occupied spaces in the building are assume to be an office or business occupancy which has a considerably smaller ventilation requirement than the assembly occupancy of the Waiting Room. Additionally these spaces have the common feature of an attic space directly above so that improvements in the envelope through the addition of roof insulation helps to reduce the overall heating and cooling load.

For the second floor spaces, we recommend putting a small heating and cooling air handling unit in the attic directly above to serve attic mounted ductwork and ceiling mounted air devices. Due to the probability that this area will have a significantly different operating schedule than the nearby assembly space, outside air for this system would be delivered via a small outside air duct connection directly to the exterior with controls to shut this connection off whenever the space is unoccupied. Alternatively if desired for increased system efficiency and if there is adequate room in the attic, the OA could be brought in via a small ERV dedicated for this space.

For the Mail and Freight Rooms that make up the balance of the occupied building, a heating and cooling air handling unit can be mounted in the adjacent boiler room since this room has a direct connection into the attic over these occupied spaces. Air would be distributed through duct mounted ductwork to ceiling mounted air devices. A dedicated ERV would be installed to serve this air handler.

Mechanical System Assessment & Feasibility Study – Keokuk Union Depot

Mechanical – Plant Level

In the previous section, we discussed what type of equipment would deliver conditioning to the spaces. We talked in general terms of “radiant heat” and “air handling units” along with the associated ERV’s and DOAS systems. We did not discuss how we would actually create the hot water to be used in the radiant floor or the heating and cooling medium that would be used by the AHU’s & DOAS machines to produce their conditioned air flow. In this section, we discuss two possible methods that might be used to achieve these desired results.

Alternative 1 – Geothermal HVAC System:

There are many different types of geothermal systems, although the only one under consideration for this project would be a closed loop ground-coupled system. While the readily accessible river water could conceivably be used in an open loop system, there are inherent issues with these types of systems that add to the on-going maintenance and operating costs making them less attractive then the closed loop alternative that is recommended. Heat pumps are widely known as the most energy efficient method to heat and cool a building however there is a premium of cost to install the closed loop piping. In a well-designed and properly installed system, this additional cost is often paid back within eight to ten years of operation. Additionally, there are federal tax incentives available to assist in decreasing the cost of installation should the organization developing the project be subject to federal tax liability and there may be state, local & utility/industry incentives that could be further explored at the time the system design and installation is implemented.

Within the closed loop category, there are additional choices of system type. The common feature in all of them is the use of stable deep earth temperatures as an energy exchange medium. A system of pipes is buried in the earth, either in a horizontal configuration when there is sufficient land available, or in a vertical arrangement when there is insufficient land as is the case on this site. Boreholes would be drilled into the available site and the closed loop piping would be inserted and grouted in place. These boreholes would extend to a depth anywhere between 150 feet and 450 feet deep depending on the final design. The boreholes would typically be drilled with a 20 feet spacing to allow for the ground mass to have sufficient volume to accept the required energy exchange. The closed loops would be connected into circuits and brought into the building at a depth not less than five feet below grade so that no part of the system would be visible. This lack of visible exterior equipment is another strong advantage of a geothermal based system when compared to a system requiring exterior heat rejection equipment such as condensing units. These circuits would be collected into a common header within the building for use by the geothermal equipment used to produce the cooling and heating effect in the building.

The two types of geothermal equipment recommended for this building are water-to-air ground-source heat pump units that directly produce cool or hot air for delivery to the spaces and water-to-water ground-source heat pump units that produce chilled or hot water for use by other systems to produce the heating and cooling effect. The geothermal loop piping would connect to each heat pump unit where a small pump would circulate water from the loop through the equipment and back into the loop in order to transfer energy as needed. In heating mode, the heat pump extracts energy from the loop while in cooling mode the heat pump rejects energy to the loop water.

In order to address the need for a very quiet air handling system in the Waiting Room due to the exposed nature of the equipment, we recommend a water-to-water heat pump be used to create chilled and hot water for use by a conventional air handling unit. By using a chilled/hot water air handling unit, there would be no need to create a roof penetration for the gas-fired furnace flue. The hot water produced by the geothermal system would also be used by the radiant floor system and cast iron radiators. The piping for this equipment would be brought to the space via the utility tunnel and/or below grade when the existing floor is replaced.

In the balance of the zones and for the DOAS unit in the second floor attic space, the most efficient method would be to use water-to-air heat pumps. These units are self-contained and would sit in place of a conventional air handling unit that would otherwise be required. These units would directly create the cooling and heating effect as called for by the system controls.

No boiler or any exterior equipment would be required although we have found some advantage in adding a supplemental boiler in some buildings. This is primarily done when the building heating load is substantially larger than the cooling load. In the case of this building, the heating and cooling loads are quite close so we do not feel a supplemental boiler is required. One additional benefit of not having a boiler would be that there is no need for a chimney or combustion air. This would allow for any modification of the existing chimney to return it to the original and common height to be done in a non-functional method which would likely decrease the cost of the renovation.

Alternative 2 – Conventional HVAC System:

The conventional HVAC system would consist of gas-fired equipment to produce the heating effect and air cooled condensing units to produce the cooling effect. In the Waiting Room, a forced air gas-fired furnace could be maintained at the same location as the existing unit although it will require a second or a single larger unit to provide the additional cooling capacity required. The flue gases and combustion air intake would continue to be routed through the adjacent roof dormer however an additional set of pipes may be required depending on the final equipment sizing. This equipment would also include a cooling coil that would be connected to a grade mounted condensing unit, most likely located on the plan north side of the building. Refrigerant piping would be extended between the air conditioning coils and the condensing units. The challenge of this solution is the desire to relocate the Toilet Rooms to create more room for the functional use of the Waiting Room venue. This might entail a new unit located above the Ticket Office or the maintenance of the platform above the Toilet Rooms to allow for the use of the existing equipment location.

A separate boiler would be required to provide the hot water needed for the radiant floor system and cast iron radiators. This boiler would be located in the boiler room and the piping would extend through the existing utility tunnel to the space. The boiler would be a side vent style which would allow for venting out the wall of the Boiler Room. Combustion air for the boiler would be provided through modification of an existing window opening. One additional benefit of having a side vent boiler would be that there is no need for a chimney. This would allow for any modification of the existing chimney to return it to the original and common height to be done in a non-functional method which would likely decrease the cost of the renovation.

The other spaces in the building would be similarly served by gas-fired furnaces and air conditioning units made up of duct or equipment mounted coils and remote condensing units. The DOAS would function best however with a hot water heating coil as the source of supplemental heat so hot water piping from the boiler would be routed to this unit as well.

The major disadvantage of the conventional system approach is related to the requirement for grade mounted exterior equipment which must be located and maintained. There is also the noise associated with this equipment which may or not be an issue on this site.

Life Cycle Cost Analysis and HVAC System Recommendation

While cost of operation is not the only reason why a geothermal system might be preferred over a conventional system, it is often the most compelling reason. In an effort to establish whether the additional cost of the more efficient geothermal system can be recovered through reduced operating costs, we have performed a Life Cycle Cost Analysis (LCCA). This analysis looks at the two proposed systems: Geothermal and Conventional and simulates their operation over a 20 year life of the system. Operational costs assumed included not only energy costs for gas & electric but also maintenance costs. A 2% per year escalation has been assumed on energy and maintenance costs to account for annual inflation.

There are actually four alternatives presented in our energy model: Alt 1) Conventional system without envelope improvements; Alt 2) Geothermal system without envelope improvements; Alt 3) Conventional system WITH envelope improvements; and Alt 4) Geothermal system WITH envelope improvements. The results for this analysis show a clear bias to the geothermal system whether envelope improvements are done or not. We see a simple payback of about 8 years in either case. The difference between the two geothermal alternates (Alt 2 & Alt 4) is the initial cost of installation. Alt 2 without envelope improvements would cost almost double the cost of Alt 4 which includes the envelope improvements. This cost savings in initial equipment costs can then be used to help fund the envelope improvements and provide for a better, more comfortable and energy efficient building.

Given the reduction in overall system capacity due to the envelope improvements and the short payback for the geothermal system when compared to a conventional system, we recommend that both the building improvements and geothermal system be included should this project move forward.

Electrical

Assuming that the envelope improvements are undertake to reduce the overall HVAC system capacity, regardless of the HVAC system selected, we recommend a new 400 Amp, 208-120 Volt, 3-Phase, 4-Wire electric service be brought into the building. If the 3-Phase service is not readily available or is cost prohibitive, a 600 Amp, 240-120 Volt, 1-Phase, 3-Wire service would suffice. Given the planned use of the building as we understand it, a single meter should be used. If separate office/business uses of portions of the building are planned then separate metering may be desired although it would be easier and less expensive to either negotiate the electric cost into the lease or provide tenant sub-metering.

A new system of electrical distribution should be provided throughout the building although areas served by conduit and modern conductors could remain and be tied into the new distribution panels. Additional distribution will be required to serve the new mechanical systems.

A new system of lighting will be required for most of the spaces and this also shall be connected to the new electric distribution system. Emergency lights and exit signs should be incorporated as well. These are typically package units with self-contained batteries but a remote battery system could be considered for emergency lighting in areas that have historic style light fixtures.

A new fire alarm system should also be provided for the building. This system would provide smoke detectors, heat detectors, manual pull stations, audible and visual annunciators and control panels as needed. The system would typically be supervised with a phone or radio connection to the local fire department or monitoring service.

The building will ultimately also need telephone and data services updated to meet the needs for the planned uses of the building spaces.

In the Waiting Room space, in lieu of exposed conduit it may be possible to install the raceway system for any ceiling mounted equipment above the roof deck at the time the roof is replaced. This would clean up the ceiling from having disruptive conduits and would also allow for a more comprehensive lighting, audio/visual and fire alarm system without the need for surface raceway.

Plumbing:

The plumbing in the building is in some cases antiquated, defunct or replaced with surface mounted piping. Depending on the final occupancy and uses of the spaces within the building, the plumbing fixture count may be inadequate. Additionally, given the nature of the installed surface mounted piping in the restrooms located in the Waiting Room, we could imagine these systems being removed and replaced as part of a larger improvement to the building. Given the age of the structure and the below grade piping, we recommend that the if these Toilet Rooms are to remain in service that the sanitary sewer serving the restrooms in the Waiting Room space be removed and replaced with modern materials whenever the proposed floor replacement would occur. Similarly, the domestic water serving these Toilet Rooms should be replaced with modern piping whenever access to the below grade piping becomes available.

If as we suspect the fixture count is inadequate, one way to avoid all of the remedial work on the plumbing piping systems serving the Waiting Room is to abandon and remove these Toilet Rooms from their current location and relocate their function into the adjacent Baggage Room area. This would allow for better use of the Waiting Room and would allow for consolidation of the needed plumbing fixtures at a new location that could also serve the Freight/Mail Room areas which will need access to some toilet facilities to be code compliant. This new location could then allow for a rippling of fixture count or as required to meet the occupancy requirements.

Given the likely increase in total fixture count for the building, a new larger water service will likely be required. This should be verified and only undertaken if warranted due to poor condition of the service piping or inadequate capacity. As noted in our review of the existing conditions, the existing water distribution piping in the tunnel currently has a leak. This piping is galvanized and it would be expected that additional performance and maintenance issues will continue until this piping is replaced. Domestic water piping to all new or existing fixtures should be replaced with modern materials.

The sanitary sewer to the building should be evaluated and since the second floor bathroom is disconnected and no longer in use this piping would need to be replaced also during any reconstitution of this bathroom. Plumbing vents that are not of modern materials should be replaced since perforation of this piping is common in old systems.

New plumbing will be required for the new HVAC systems. This will include floor and/or hub drains and make-up water connections.

Mechanical System Assessment & Feasibility Study – Keokuk Union Depot

Budgetary Cost Estimate

Our budgetary cost estimates for the systems and improvements noted above are as follows:

Mechanical:

- Alternative 1 – Geothermal HVAC System	$ 195,000
- Alternative 2 – Conventional HVAC System	$ 154,000

Electrical:

- New electric service, distribution and fire alarm system	$ 104,000

Plumbing:

- New water service, interior & below grade water, waste & vent piping for existing fixture configuration only – does not include possible new fixture requirements	$ 66,000