



2009

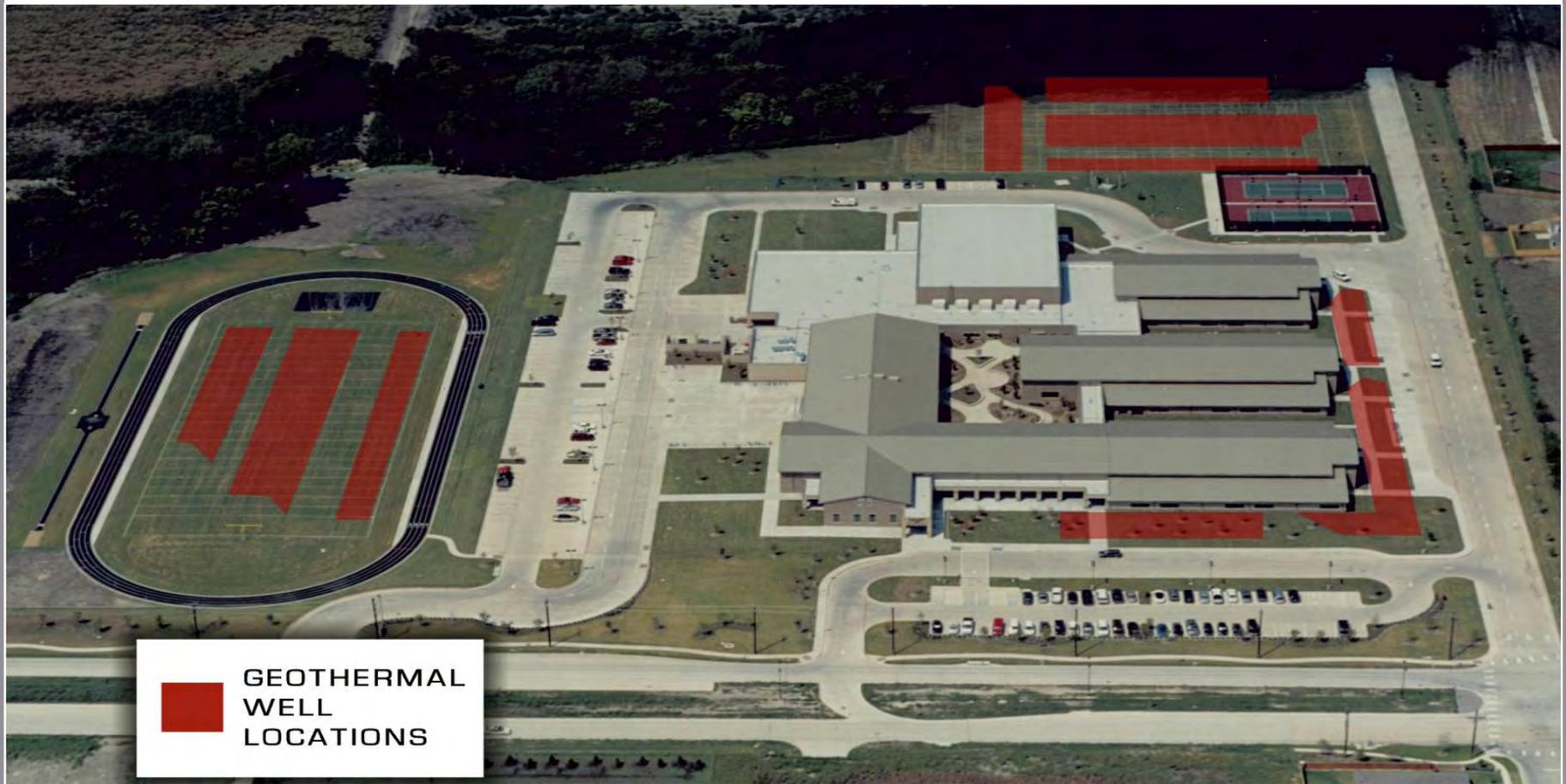
GEOHERMAL/ GEOEXCHANGE/ GROUND COUPLED HEAT PUMP SYSTEMS



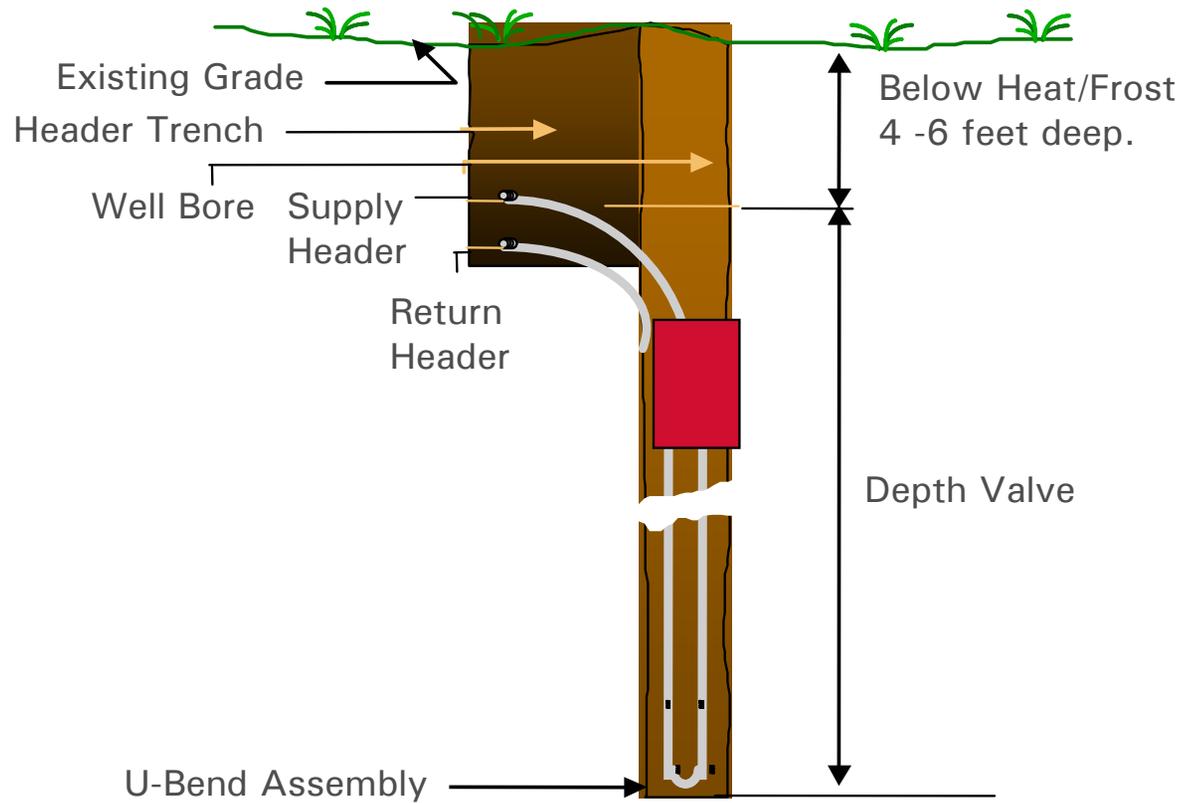
WHAT IS A GEOHERMAL HEAT PUMP SYSTEM?

- GSHPs are a cost effective, energy efficient, and environmentally friendly. DOE and the EPA have endorsed the technology as a Renewable Resource.
- GSHPs reliably deliver quality air-conditioning and heating, on demand, in every season
- GSHPs works for new construction and retrofits of older buildings. Their flexible design requirements make them a good choice for schools, high rises, government buildings, apartments and restaurants – almost any commercial property.
- GSHPs have lower operating and maintenance costs.
- GSHPs are durable with life cycle that exceeds today's building designs.
- GSHP's comply with all Code and ASHRAE Standards, including ASHRAE 62 Ventilation requirements and ASHRAE 90 Energy Standards.
- EPA indicates geoexchange is the most energy-efficient, environmentally clean and cost-effective space conditioning system available.

WHERE DOES GEOTHERMAL WORK? WHERE DOES IT NOT WORK?



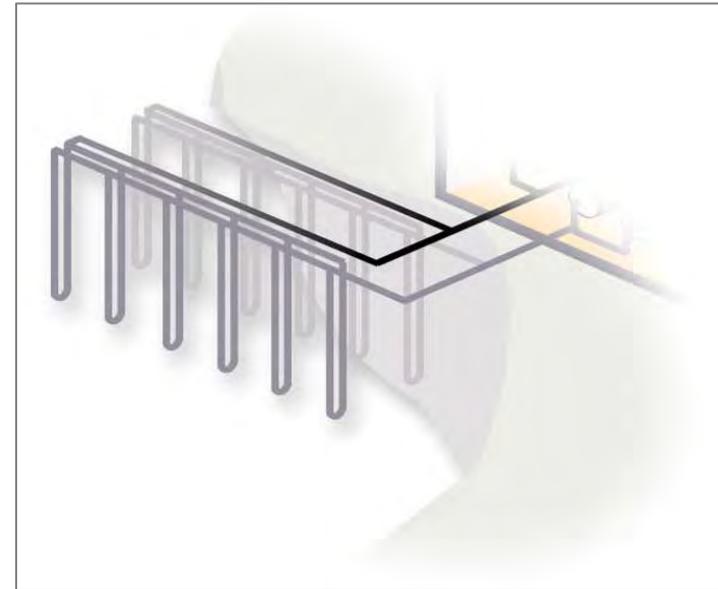
HOW DOES GEOTHERMAL WORK? TYPICAL WELL BORE



GEOHERMAL WELLS AND WELL FIELD

- 5" Bore – Typically 200 to 400 feet deep
- 1" U-Bend HDPE
- Filled with Bentonite Grout
- Space 15 to 20 feet apart
- Header in reverse return configuration
- Maximum Header size is 4" – approximately 70 tons
- Prefer to have fields no more than 3 to 5 wells wide – avoid the checkerboard scenario
- Vertical Wells - Advantages
 - Requires least amount of land
 - Least amount of total piping
 - Least amount of Pumping Energy - less than 25 feet of head
 - More Consistent Ground Temperature versus Horizontal Well Fields
 - **Well Field square footage similar to square footage of space being conditioned**

PREFERRED WELL FIELD DESIGN



WELL FIELDS



WELL FIELD AND HEADERS



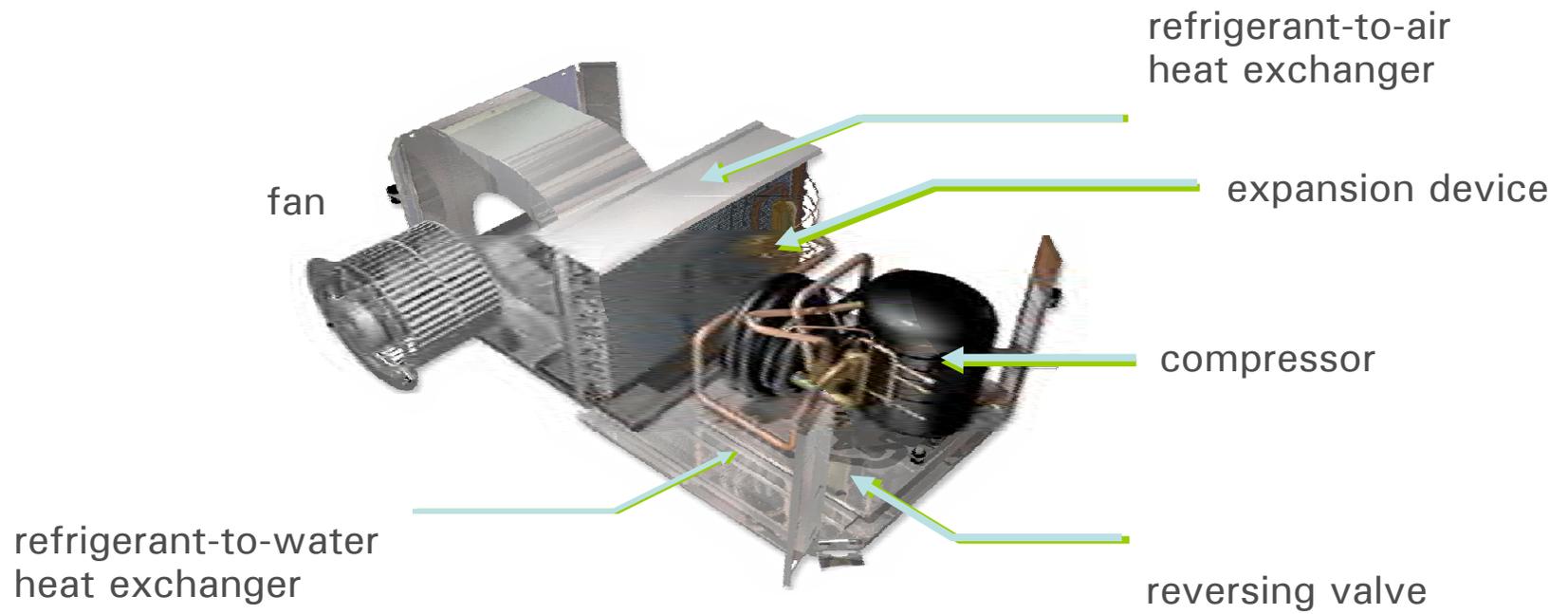
PURGE PORT ARRAY



TYPICAL PURGE PORT ARRAY



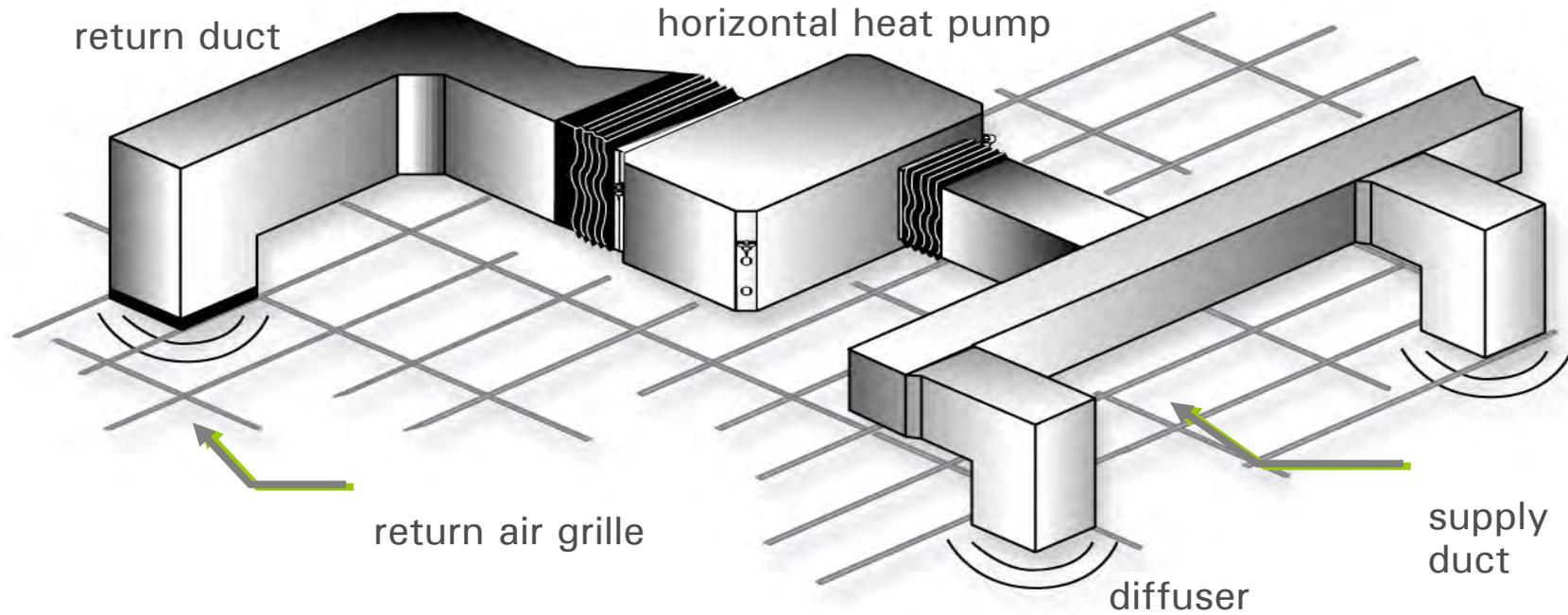
COMPONENTS OF A GHP (GEOHERMAL HEAT PUMP)



SIDE VIEW – UNIT INSTALLATION



TYPICAL CLASSROOM AIR DISTRIBUTION SYSTEM



GEOHERMAL SYSTEM – BENEFITS/ INTANGIBLES



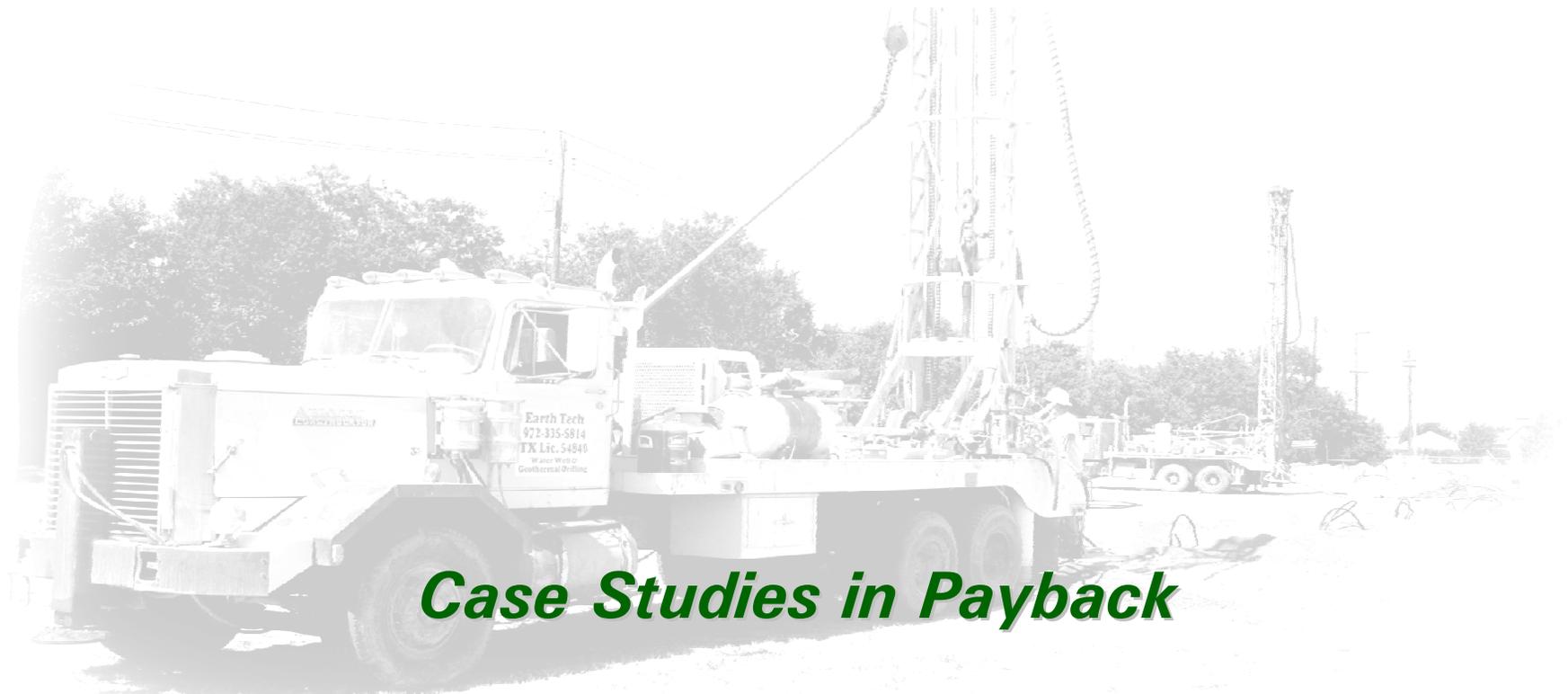
- Environment
 - “Renewable Resource” Tax Credits
 - USGBC Approved: 8-10 LEED points
 - IAQ Friendly: Increased latent capacity improves humidity control vs. RTUs
 - No water treatment: Water resource not required
 - For every hour of use, a geoexchange system produces one pound less CO₂ than a conventional HVAC system.
 - No on-site combustion, no carbon monoxide
- Efficient/ Reliable
 - 30-45% less energy cost annually
 - Performs both cooling and heating efficiently (Heat supply 100F+)
 - Well field 50+ year solution
 - Single unit failure does not affect the rest of the system
 - 160+ installations and 600+ schools in US – Not and experiment

GEOHERMAL SYSTEM – BENEFITS/ INTANGIBLES



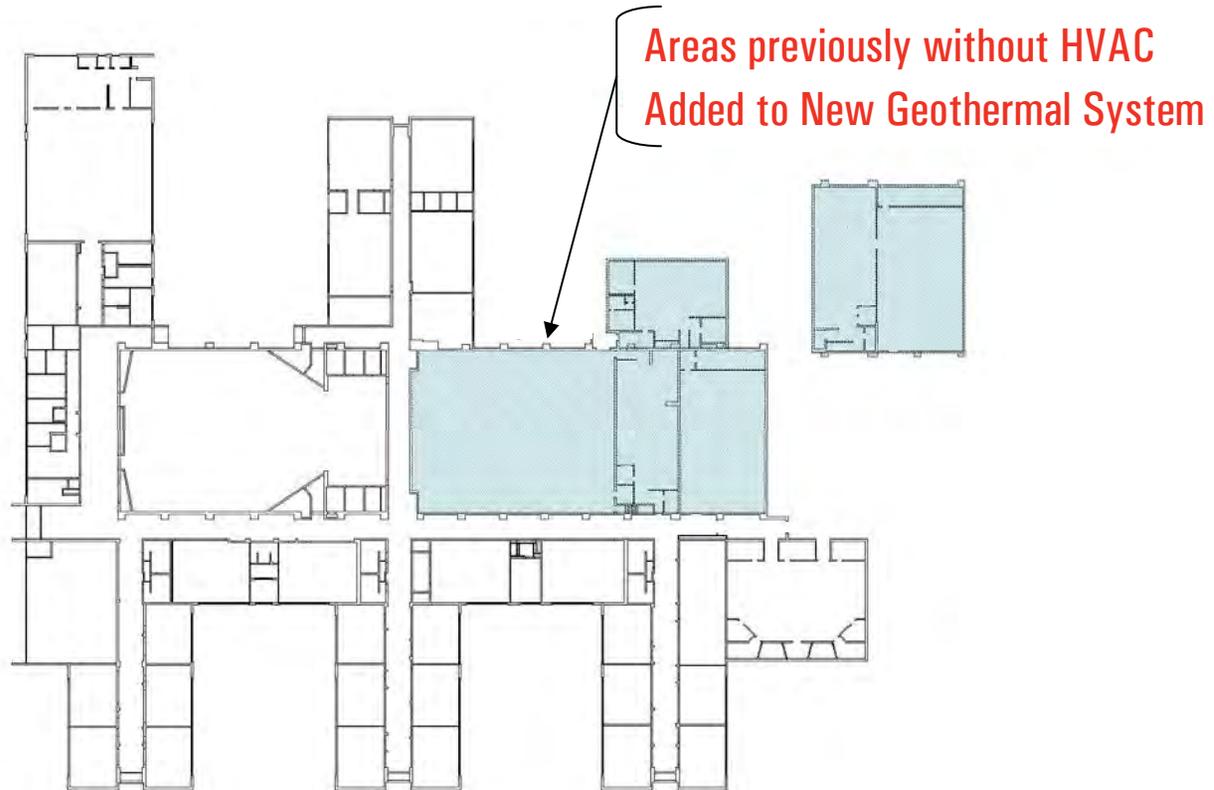
- Economical
 - Less first cost than Central Plant
 - Competitive option for retrofit projects
 - No water resource required – closed loop system
 - No exterior equipment
 - No vandalism, hail/ sun damage or roof leaks
 - Maintains roof/ envelope integrity
 - Low parts and labor costs,
 - No Annual On-Call fees
- Functional
 - Simple individual space control
 - Dedicated unit/ pump per classroom on Zone
 - Flexible Design: Single building or entire campus; single level building or multi-story building
 - Flexible construction for future renovations/ additions/ internal spatial changes

GEOHERMAL HEAT PUMP SYSTEMS

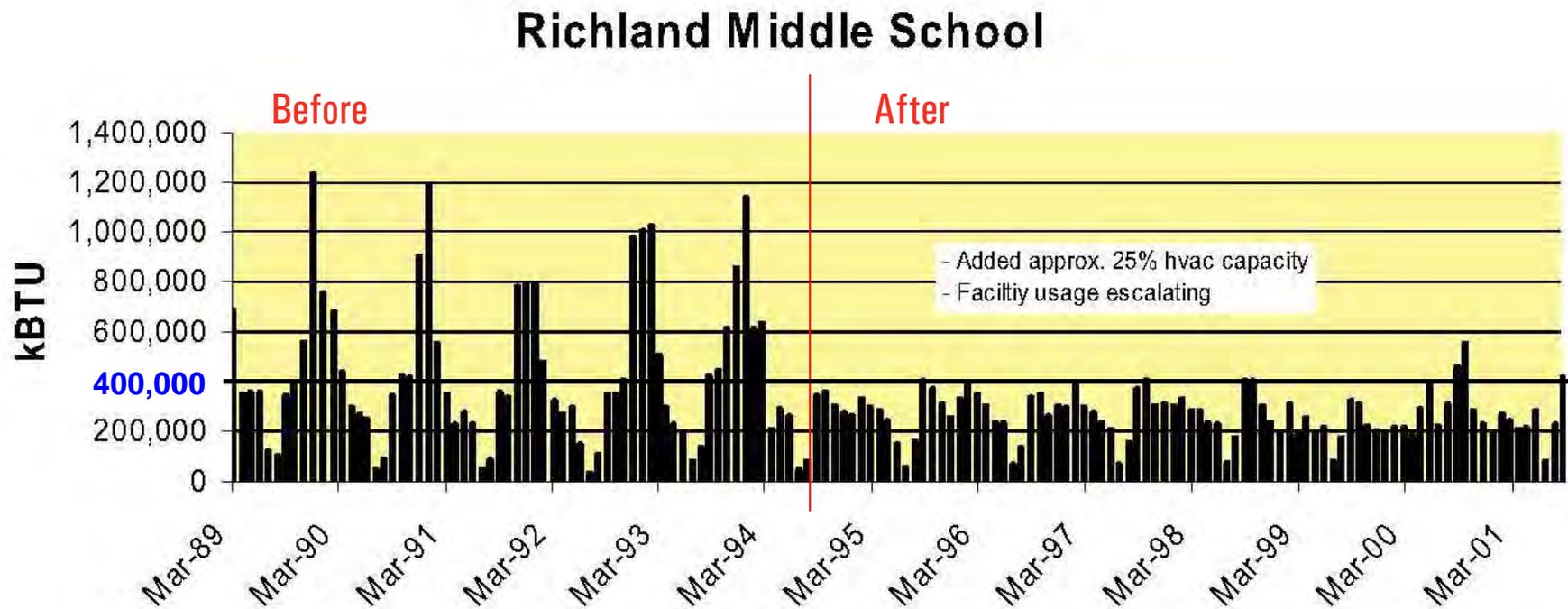


Case Studies in Payback

RICHLAND MIDDLE SCHOOL Geothermal Conversion of Entire School

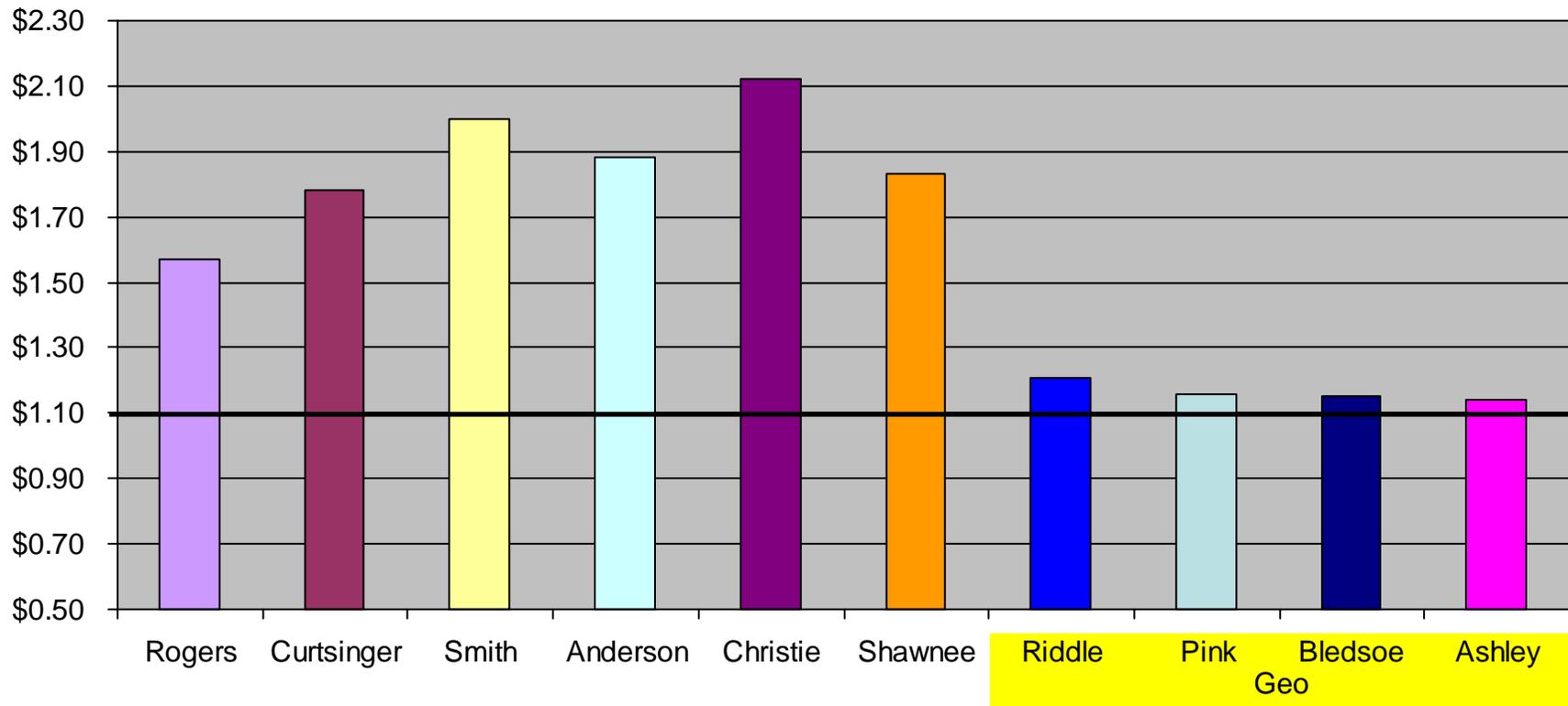


RICHLAND MIDDLE SCHOOL – BISD | GEOTHERMAL SYSTEM INSTALLED IN 1995

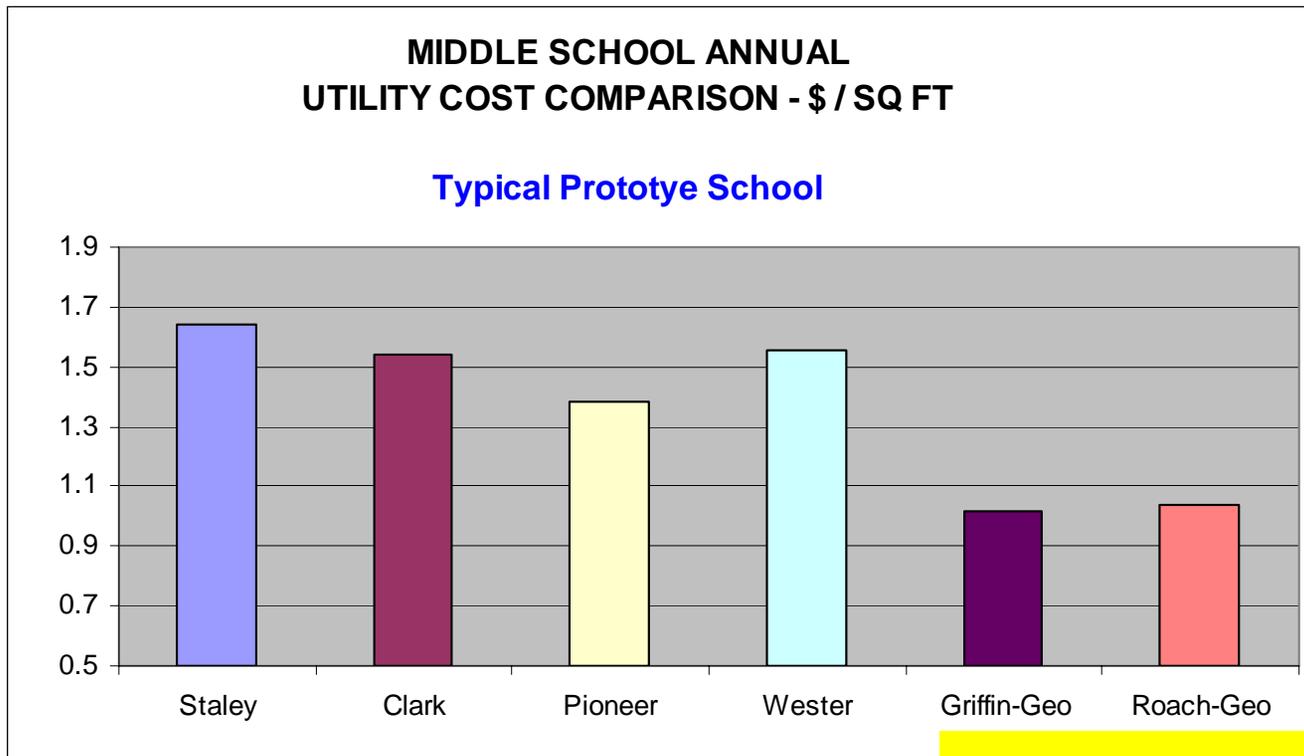


FRISCO ISD HIGH SCHOOLS COMPARISON – YEAR 2005 - 2006

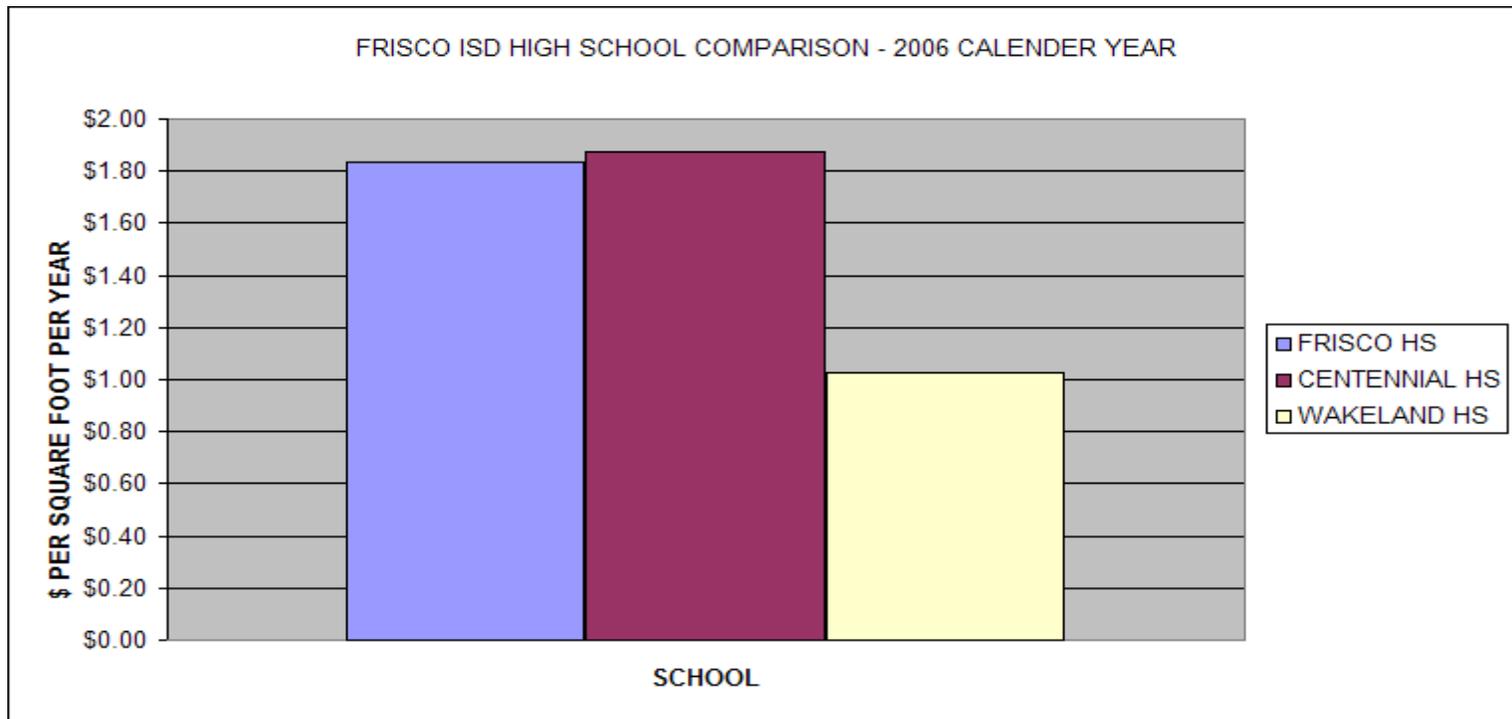
ELEMENTARY SCHOOL ANNUAL UTILITY COST COMPARISON - \$/ SQ FT



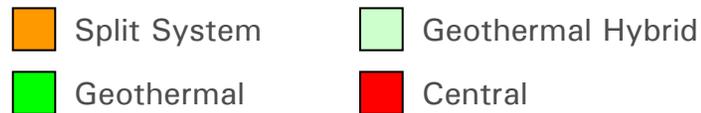
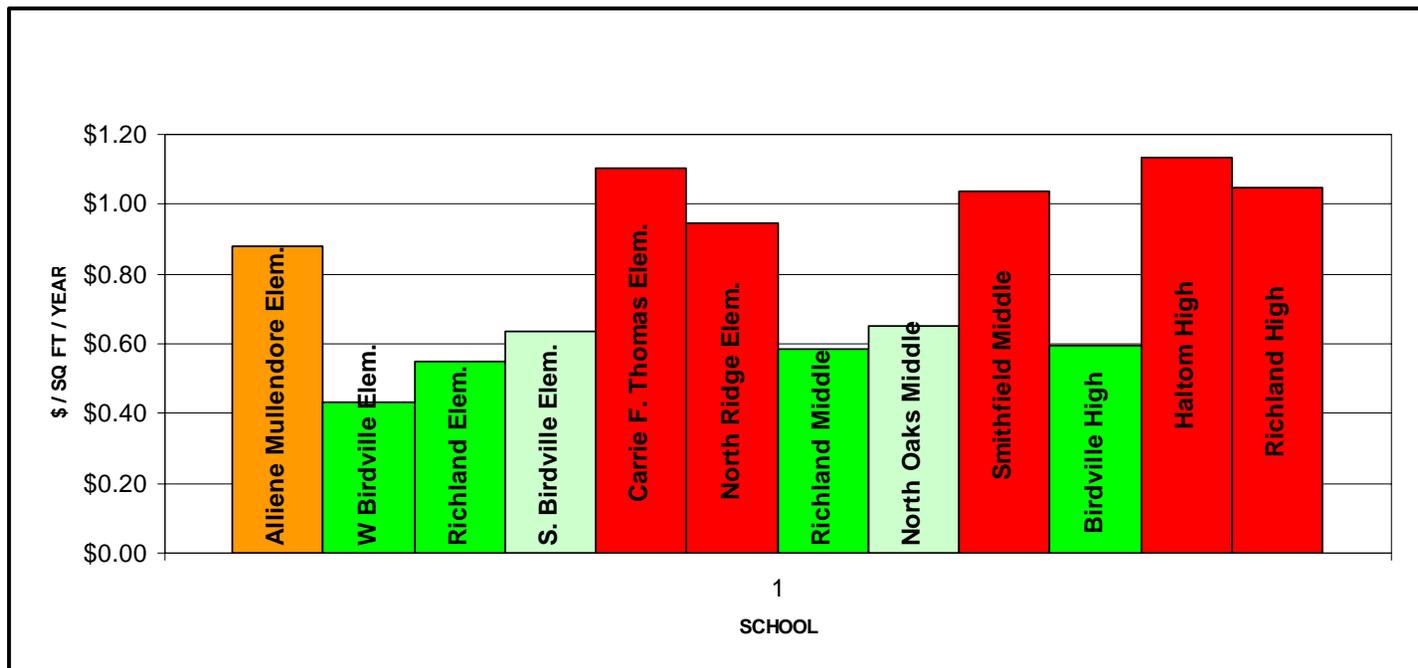
FRISCO ISD SCHOOLS COMPARISON – YEAR 2005 - 2006



FRISCO ISD HIGH SCHOOLS COMPARISON – YEAR 2006



BIRDVILLE ISD COMPARISON – YEAR 2001 - 2002



FRISCO ISD SCHOOLS MECHANICAL COST COMPARISON

| CAMPUS | YEAR BID | SQ FT | MECH COST* | \$/ SF |
|-------------------------|-------------|---------|-------------|---------|
| Bright Elementary | 2001 | 71,860 | \$968,922 | \$13.48 |
| Spears Elementary | 2002 | 74,555 | \$970,621 | \$13.56 |
| Riddle Elementary – Geo | 2003 | 72,848 | \$981,284 | \$13.47 |
| Pink Elementary – Geo | 2004 | 76,000 | \$1,054,261 | \$13.87 |
| Pioneer Middle | 2001 | 137,245 | \$1,676,435 | \$12.21 |
| Wester Middle | 2001 | 137,245 | \$1,676,435 | \$12.21 |
| Griffin Middle – Geo | 2002 | 138,651 | \$1,679,000 | \$12.11 |
| Roach Middle – Geo | 2004 | 138,650 | \$1,709,000 | \$12.33 |

- Includes Controls and Condensate Drains / Costs are not adjusted for inflation or escalation
- 2006 Costs are \$15 to \$16 per square foot

ASHRAE Research Project 929

Final Report

Table C-8a. Statistics for Total HVAC Maintenance Costs for Individual Facilities with In-House HVAC Maintenance Personnel When Classified by Type of Distribution System Used in Facilities (Costs in Cents per Square Foot)*

| <i>Type of Distribution System</i> | <i>Number of Facilities</i> | <i>Mean Cost</i> | <i>Standard Deviation</i> | <i>25th Percentile Cost</i> | <i>Median Cost</i> | <i>75th Percentile Cost</i> |
|-------------------------------------|-----------------------------|------------------|---------------------------|-----------------------------|--------------------|-----------------------------|
| Single zone | 30 | 53.08 | 70.49 | 15.70 | 31.60 | 61.90 |
| Multi-zone | 21 | 45.49 | 34.54 | 21.90 | 30.00 | 68.00 |
| Dual duct | 8 | 48.41 | 30.82 | 23.95 | 55.55 | 68.90 |
| Variable-air-volume | 52 | 38.26 | 44.36 | 9.45 | 26.95 | 51.90 |
| Constant volume | 23 | 47.25 | 36.95 | 19.70 | 37.50 | 78.80 |
| Two-pipe fan coil | 12 | 36.58 | 30.36 | 8.15 | 36.00 | 55.70 |
| Three-pipe fan coil | 1 | 44.00 | n/a | 44.00 | 44.00 | 44.00 |
| Four-pipe fan coil | 8 | 53.05 | 34.17 | 31.95 | 44.65 | 81.35 |
| Induction | 6 | 57.48 | 37.16 | 39.10 | 46.15 | 92.50 |
| Baseboard and finned-tube radiation | 1 | 78.20 | n/a | 78.20 | 78.20 | 78.20 |
| Radiant panel | 3 | 38.10 | 30.75 | 8.40 | 36.10 | 69.80 |
| Unit ventilators | 7 | 67.46 | 54.18 | 8.40 | 68.00 | 131.30 |
| Valance unit | 1 | 69.80 | n/a | 69.80 | 69.80 | 69.80 |
| Packaged terminal air conditioners | 6 | 48.55 | 36.79 | 8.40 | 52.95 | 69.80 |
| Water-source heat pumps | 4 | 113.85 | 109.20 | 50.90 | 74.30 | 176.80 |
| Packaged terminal heat pumps | 1 | 69.80 | n/a | 69.80 | 69.80 | 69.80 |
| Geothermal heat pump system | 41 | 18.44 | 26.09 | 3.70 | 6.70 | 20.20 |
| Other heat pump system | 4 | 56.00 | 67.40 | 11.30 | 31.75 | 100.70 |
| Other types | 24 | 8.73 | 10.39 | 1.95 | 5.85 | 11.35 |

GEOHERMAL/ GEOEXCHANGE/ GROUND COUPLED HEAT PUMP SYSTEMS



Life Cycle Cost Analysis

| BIRDVILLE ISD - RETROFIT HVAC LIFE CYCLE COST FOR ELEMENTARY SCHOOLS | | | | | | |
|---|----------------------------|---------------------------|-------------------------------|--------------------------------|---------------------------|------------------------|
| IMAGE ENGINEERING GROUP, LTD | | | | GRAPEVINE, TEXAS | | |
| SYSTEM TYPE | TOTAL SYSTEM COST** | ANNUAL MAINT COSTS | ANNUAL ENERGY COSTS ** | SIMPLE PAYBACK (YEARS)* | 20 YEAR LIFE CYCLE | REMARKS |
| ELEMENTARTY CAMPUS (PROJECTS INSTALLED IN 1995) | | | | | | |
| AIR COOLED HEAT PUMPS (BISD MULLENDORE ELEM)(129 TONS) | | | | | | |
| AIR COOLED HEAT PUMPS | \$265,198.00 | \$12,033.33 | \$40,626.00 | 0.0 | \$1,265,345.07 | RTU REPLACE AT YEAR 15 |
| GEOHERMAL HEAT PUMPS (BISD RICHLAND ELEM)(121 TONS) | | | | | | |
| GEO UNITS AND WELL FIELD | \$266,940.00 | \$8,500.00 | \$33,534.00 | 0.2 | \$840,680.00 | |
| LIFE CYCLE COST SAVINGS | | | | | \$424,665.07 | |

* PAYBACK BASED ON ENERGY AND MAINTENANCE SAVINGS ONLY

** COSTS ARE ACTUAL, NOT ADJUSTED FOR INFLATION OR ESCALATION AND INCLUDE CONTROLS

FRISCO ISD - ACTUAL HVAC LIFE CYCLE COST FOR MIDDLE SCHOOL PROJECTS

| <i>IMAGE ENGINEERING GROUP, LTD</i> | | | | | | | <i>GRAPEVINE, TEXAS</i> |
|---|---------------------|--------------------|------------------------|-------------------------|--------------------|---------|-------------------------|
| SYSTEM TYPE | TOTAL SYSTEM COST** | ANNUAL MAINT COSTS | ANNUAL ENERGY COSTS ** | SIMPLE PAYBACK (YEARS)* | 20 YEAR LIFE CYCLE | REMARKS | |
| CAMPUS - 138,000 SQ FT | | | | | | | |
| FOUR PIPE SYSTEM (GAS BOILER AND AIR COOLED CHILLER (BUILT IN 2001)) | | | | | | | |
| GAS / ELECTRIC BOILER / CHILLER | \$1,676,435.00 | \$43,700.00 | \$213,091.13 | 0.0 | \$5,135,822.60 | | |
| GEOHERMAL HEAT PUMPS (BUILT IN 2004) | | | | | | | |
| GEO UNITS AND WELL FIELD | \$1,709,000.00 | \$27,600.00 | \$143,651.38 | 0.4 | \$3,425,027.60 | | |
| LIFE CYCLE COST SAVINGS | | | | | \$1,710,795.00 | | |

* PAYBACK BASED ON ENERGY AND MAINTENANCE SAVINGS ONLY

** COSTS ARE ACTUAL, NOT ADJUSTED FOR INFLATION OR ESCALATION AND INCLUDE CONTROLS

| FISD/MISD - HVAC LIFE CYCLE COST FOR NEW ELEMENTARY SCHOOLS | | | | | | |
|---|----------------------------|-------------------------------|-------------------------------|--------------------------------|-----------------------------|----------------|
| IMAGE ENGINEERING GROUP, LTD | | | | GRAPEVINE, TEXAS | | |
| SYSTEM TYPE | TOTAL SYSTEM COST** | ANNUAL MAINT COSTS**** | ANNUAL ENERGY COSTS ** | SIMPLE PAYBACK (YEARS)* | 20 YEAR LIFE CYCLE** | REMARKS |
| ELEMENTARY CAMPUS (2004 PROJECTS) | | | | | | |
| MISD ROOFTOP UNITS (TRANE VIPER WITH ECONOMIZERS AND DEMAND CONTROL VENTILATION) 79274 SQ FT | | | | | | |
| TRANE VIPER HEAT PUMPS | \$908,993.00 | \$24,495.67 | \$97,733.90 | 0.0 | \$3,080,886.42 | RTU REPLACE |
| FOR REFERENCE: CONTROLS COST \$184,500.00 (INCLUDED IN TOTAL SYSTEM COST) | | | | | | AT YEAR 15*** |
| FISD GEOTHERMAL HEAT PUMPS (WITH ENERGY RECOVERY) 76000 SQ FT | | | | | | |
| GEO UNITS AND WELL FIELD | \$932,070.00 | \$14,014.40 | \$88,379.35 | 1.2 | \$2,047,875.00 | |
| FOR REFERENCE: CONTROLS COST \$60,048 (INCLUDED IN TOTAL SYSTEM COST) | | | | | | |
| LIFE CYCLE COST SAVINGS | | | | | \$1,033,011.42 | |

* PAYBACK BASED ON ENERGY AND MAINTENANCE SAVINGS ONLY

** COSTS ARE ACTUAL, NOT ADJUSTED FOR INFLATION OR ESCALATION AND INCLUDE CONTROLS (NOTE DIFFERENT ELEC PROVIDERS AND COST POINTS) ENERGY COSTS HAVE BEEN NORMALIZED BASED ON UTILITY UNIT COSTS

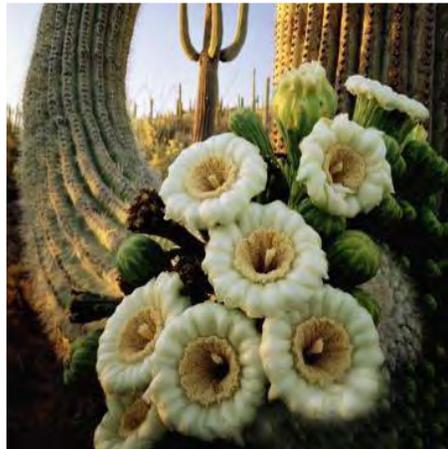
*** ASHRAE LIFE FOR RTUs - 15 YEARS / ASHRAE LIFE FOR GEO UNITS >24 YEARS

**** MAINTENANCE COSTS INFO FROM "HVAC MAINTENANCE COSTS-ASHRAE RESEARCH PROJECT 929-JUNE1999-FOR FACILITIES WITH IN-HOUSE MAINTENANCE



ANALYSIS

- Use Historical or Industry supported data; ASHRAE, AEE, DOE, EPA
- Use simulation models that have been “tweaked” against actual experience data; energy costs, installation costs, etc
- Keep calculations simple, limit evaluation to main cost items; energy, installation and maintenance. (may depend on your audience/client for the level of detail or complexity)



THANK YOU FOR YOUR TIME.