B trombe retaining wall
conclusion
An evaluation of this project might suggest it is a proposal for a new lifestyle. In reality, it is only a variation of an accepted lifestyle, with an attempt made to maximize on potential offered by the environment itself. The program which ordered the design is based on an overlapping set of priorities. At each scale of design there is an overall concept of a central or focus point and radiating or "spoke" relationships. Ordering these further is the importance of southern orientation and the topography, be it level or sloping.

The results afforded by the above criteria suggest a variety of spatial experiences.

--Land as a bridge--land connecting two masses with man-made space contained within (as opposed to the man-made bridging the natural)
--New topography--a topography created by the existence of a community within, the ability to provide seclusion of areas desired (individual units--atriums, etc.) or courtyard entry to units
--Contrast of natural with man-made--

Coordinating the soft lines of nature with the geometric of man-made, each accentuating the other.

--Last, and perhaps most essential for a design of subterranean spaces, the new definitions of "inside" and "outside". The design tries to reverse the two definitions: outside spaces are treated as indoor ones, and indoor ones are, in turn, fused with an outdoor space. Landscape is more than just a backdrop for design--it is merged with architecture until the two are one.

Jaane Scheidler
ACKNOWLEDGMENTS

I'd like to thank the instructors who helped me while working on this project, making me always look one step farther, and whose enthusiasm never failed:

Robert Fisher—architectural critic
Robert Koester—arch. critic
Joseph Cascio—landscape arch. critic
appendix
building types study

In this section I divided the study into 3 parts: Underground, Solar, and Community. In each I tried to analyze what the organizing factors of the design were, and to correlate any factors overlapping between each category.
SOLARIA MALCOLM B. WELLS
SHAMONG TOWNSHIP, NEW JERSEY

BUILDING TYPES STUDY

STRUCTURE - AS A DETREMINANT OF THE FORM

1. ORIENTATION TO THE SUN
2. SLOPE OF ROOF
   a) SUPPORTS SOIL

BASIC SHAPE EVOLVED:
LINEAR SEGMENTED FORM

SECTION

PLAN
SOLARIA MALCOLM B. WELLS
SHAMONG TOWNSHIP, NEW JERSEY

BUILDING TYPES STUDY

SPACE -
AS A DETERMINANT OF THE FORM

1. ZONING
   a) PUBLIC TO PRIVATE
   b) SERVICE

2. CIRCULATION
   a) LINEAR

SECTION

PLAN

PRIVATE
SERVICE
PUBLIC
SOLAR HOUSE DON IVATSON
GUILFORD, CONNECTICUT

BUILDING TYPES STUDY

SITING -
AS A DETERMINANT OF THE FORM
1. ORIENTATION TO THE SUN
2. SUN ANGLE/SLOPE OF ROOF

SPACE -
AS A DETERMINANT OF THE FORM
1. ZONING
   a) PUBLIC TO PRIVATE
   b) DIFFERENT LEVELS

ISOMETRIC

2ND FLOOR PLAN
PRIVATE SPACE

1ST FLOOR PLAN
PUBLIC SPACE
SOLAR PROTOTYPE THE ARCHITECT
TAOS, NEW MEXICO
BUILDING TYPES STUDY

SITING -
AS A DETERMINANT OF THE FORM:
1. ORIENTATION TO THE SUN
2. THERMAL STORAGE TANKS
   a) GROUPING OF SPACES
      BASED ON THESE

SPACE -
AS A DETERMINANT OF THE FORM:
1. CIRCULATION
2. ZONING
   a) PUBLIC
   b) PRIVATE
   c) SERVICE

PRIVATE
2ND FLOOR PLAN

PUBLIC
1ST FLOOR PLAN

SOUTHERN EXPOSURE

KOMETRIC
UNDERGROUND OFFICE  M.B. WEIS
CHERRY HILL, NEW JERSEY

BUILDING TYPES STUDY

SPACE -
AS A DETERMINANT OF THE FORM
1. ZONING
   a) PUBLIC/PRIVATE
2. COURTYARD
   b) SPACES ORIENTED AROUND IT

SITING -
1. BOUNDARIES
   a) UNDERGROUND

PRIVATE
PUBLIC
PLAN
SECTION
ECOLOGY HOUSE  JOHN BARNARD  HARSTON MILLS, MASSACHUSETTS

BUILDING TYPES STUDY

SPACE -
  AS A DETERMINANT OF THE FORM
  1. ATRIUM
     a) SPACES ORIENTED AROUND IT

SITING -
  BOUNDARIES
  a) UNDERGROUND

PLAN

SECTION
UNDERGROUND CITY MALCOLM B. WELLS
PROTOTYPE

BUILDING TYPES STUDY

SPACE-

AS A DETERMINANT OF THE FORM:

1. LIGHT WELL
2. HOUSING ORIENTED AROUND IT

SITING-

1. BOUNDARIES
2. UNDERGROUND

HOUSING AT THE SULIT
CIRCLED BY COMMERCE
RECREATION
GOVERNMENT
& INDUSTRY

SECTION
CALIFORNIA CO-OP  BOB EVANS
SOUTHERN CALIFORNIA

BUILDING TYPES STUDY

CIRCULATION -
AS A DETERMINANT OF THE FORM
1. CIRCULAR CONCEPT
2. ALL FORMS EQUAL

STRUCTURE -
1. MODULES ORIENTED AROUND CENTRAL CO-OP

CONCEPT

PLAN

SECTION
SPACE -

AS A DETERMINANT OF FORM:

1. ZONING
   a. BY FUNCTION
      ☐ CIRCULATION
      ☐ RESIDENTIAL
      ☐ COMMERCIAL
      ☐ PUBLIC FACILITIES
      ☐ RECREATION

CONCEPT -

ROOSEVELT COMMUNITY
EARL SWENSSON
SPRINGFIELD, ILLINOIS

BUILDING TYPES STUDY
GADEKÆRET
COPENHAGEN, DENMARK

BUILDING TYPES STUDY

SPACE-

AS A DETERMINANT OF FORM
1. ZONING
2) PUBLIC TO PRIVATE

CONCEPT-

PUBLIC
PRIVATE

PLAN
climatic data
INTRODUCTION

Climate is the primary supporting issue for underground housing, mainly due to the fact that below the surface of the earth all climates begin to merge into one neutral one.

The United States is one of the few countries which contain such a wide range of climates. For this reason different issues would present themselves as the critical design criteria for solar underground housing, depending upon the climate and geographic make-up of that particular region.

There is a certain overlapping set of parameters which outline different areas as being most suitable for a project such as this for maximum benefit due to humidity, ground temperatures, hours of winter sunshine, etc. When we look at each set of criteria separately, and then assimilate it as an entirety, we can locate areas of the country where this project would have optimum benefit.

SEE HOW UNDERGROUND TEMPERATURES SMOOTH OUT CLIMATIC EXTREMES!

SUMMER
SUNNY AFTERNOON

<table>
<thead>
<tr>
<th>SUMMER TEMP</th>
<th>FEET ABOVE GROUND</th>
<th>WINTER TEMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>82°F</td>
<td>10'</td>
<td>27°F</td>
</tr>
<tr>
<td>64°F</td>
<td>8'</td>
<td>27°F</td>
</tr>
<tr>
<td>55°F</td>
<td>6'</td>
<td>27°F</td>
</tr>
<tr>
<td>47°F</td>
<td>4'</td>
<td>26°F</td>
</tr>
<tr>
<td>90°F</td>
<td>2'</td>
<td>24°C</td>
</tr>
</tbody>
</table>

GROUN DL EVEL

<table>
<thead>
<tr>
<th>GROUND LEVEL</th>
<th>FEET BELOW GROUND</th>
</tr>
</thead>
<tbody>
<tr>
<td>59°F</td>
<td>2'</td>
</tr>
<tr>
<td>58°F</td>
<td>4'</td>
</tr>
<tr>
<td>56°F</td>
<td>6'</td>
</tr>
<tr>
<td>55°F</td>
<td>8'</td>
</tr>
<tr>
<td>54°F</td>
<td>10'</td>
</tr>
</tbody>
</table>

WINTER
EARLY MORNING

House Beautiful, August, 1950
This map is based on scientific interpretation of regional ground temperatures made by Dr. Per Stiple, House Beautiful's chief climatologist, whose idea it is that ground temperatures can be used to soften the sharp edge of seasonal extremes.

It shows where the underground can be harnessed to keep you cool in summer and warm in winter.

Area shown advantage. The southwestern end of this zone has less summer benefit because it is drier. Also, yearly temperature extremes are not as great. Northern portions of this zone, with cool summers, would need to use sun's heat to take summertime chill off a sunken living room, but wintertime benefits would be very positive.

This area has both summer and winter advantages. But due to high relative humidities, a sunken room in this zone would require some mechanical air-drying to prevent condensation on walls, floors, etc. It is in the zone that completely, or partially, air conditioning would be most economical, and within the range of most people.

Area where underground living offers minor advantage for the following reasons: because climate above ground is pleasant and extreme temperature changes are not great extremes, or because underground temperatures are not different enough to correct the above-ground climate, or because of the complications of extreme humidity.

AREAS OF SUITABILITY FOR UNDERGROUND
Soils

Loose, porous soil that has good drainage is best

Critical factors:
- Depth to bedrock
- Depth to water table
- Unit weights of soil
- Water holding capacity (loadings required for sizing of structural members)
- Cohesiveness
- Structural behavior
- Bearing strengths
- Engineering mechanics of soils

Ground cover vegetation:
- Maintains steep and newly graded slopes
- Unifies soil surface
- Helps prevent water run-off

Chart showing percent clay, silt, and sand in the soil textural classes of U.S. Department of Agriculture
Drainage
(& water table) Good drainage important on site
Essential to drain soil water away from building as soon and
as fast as possible (both surface and subsurface)
Prevent seepage downward along the wall
Must waterproof all below grade construction
In most cases, should be protected from penetration by
plant and tree roots, excavation, etc. by outer layer of
wood or protective material.
Often suggested to seal the surface around the perimeter of
the building with an impervious layer of asphalt or concrete
to deflect water away from the building.

TYPICAL LOADING PRESSURES ON AN UN-
DERGROUND STRUCTURE IN A SOIL ENVIR-
ONMENT. HYDROSTATIC PRESSURES OCCUR
IN PRESENCE OF GROUNDWATER.

(ADAPTED AFTER DeSALVO, B.R.)
In areas with a seasonally high water table (large head of 3' or 4') it is suggested to put in a drain and filter soil system.

Filter soil (sand or gravel) often used beneath slab to reduce capillary rise to the floor slab.

Backfill--

A fast-draining highly permeable soil preferred over dense, compacted one (will reduce earth pressure on the wall and minimizes retention of infiltration and capillary moisture)

Water table higher than the floor slab--

Underfloor drains may also be required.

<table>
<thead>
<tr>
<th>Ground temperature</th>
<th>Subterranean housing would have maximum benefit where the seasonal ground temperatures are closer to the &quot;comfort zone&quot; than the air temperatures.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind</td>
<td>In the United States the warm winds are characteristically from the southwest and the winter winds from the northwest. These would vary according to region and immediate topography.</td>
</tr>
<tr>
<td>Humidity</td>
<td>Underground housing best in areas of lower humidity, but can be controlled by dehumidification in other areas.</td>
</tr>
<tr>
<td>Rain</td>
<td>Good drainage of the site necessary.</td>
</tr>
<tr>
<td>Temperatures</td>
<td>Subterranean housing finds optimal benefits in areas of extreme heat or cold.</td>
</tr>
</tbody>
</table>

- Improved insulation
- Reradiation
- Decreased infiltration
- Decreased wind chill
<table>
<thead>
<tr>
<th>Percentage sunshine</th>
<th>Solar energy maximizes benefits in areas of maximum sunshine and maximum winter cold (for heating) or summer heat (for cooling benefits)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skycover</td>
<td>Effectiveness of solar collector dependent upon a minimal amount of skycover.</td>
</tr>
<tr>
<td>Orientation</td>
<td>Sun--</td>
</tr>
<tr>
<td></td>
<td>Essential to be oriented to the south with only minor deviations to the east or west (for solar energy)</td>
</tr>
<tr>
<td></td>
<td>Wind--</td>
</tr>
<tr>
<td></td>
<td>Should be oriented to avoid direct winter winds if possible</td>
</tr>
</tbody>
</table>
COLLINS W. R. WATER ISOHERMS: GROUND TEMPERATURE DISTRIBUTION IN THE UNITED STATES
PREVAILING DIRECTION AND MEAN SPEED (M.P.H.) OF WIND
ANNUAL

NOTE:
Arrows fly with wind,

Scale for the 48 Contiguous States in Map Above:

Scale 1: 20,000,000

ALBERS EQUAL AREA PROJECTION-STANDARD PARALLELS 29½° AND 45½°
solar project

This project goes through the process of evaluating heat loss and heat gain of an underground dwelling utilizing passive solar energy.
INTRODUCTION

The program requirements for this project were:

* Underground house (Southern hillside, no trees)
* Passive solar heat

Living Room
Dining
Utility
Kitchen
Study
Bedroom (2)
Bath
Studio

Approx. 1500 ft²

Site: Huntington, Indiana
Southern slope of 20° hill
No trees on site

Soil: Milton-Randolph-Farmington
Ground temp. 6' below approx. 50°
<table>
<thead>
<tr>
<th></th>
<th>Y</th>
<th>j</th>
<th>f</th>
<th>m</th>
<th>a</th>
<th>m</th>
<th>j</th>
<th>j</th>
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<th>o</th>
<th>n</th>
<th>d</th>
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<td><strong>NORMAL TOTAL</strong></td>
<td>6205</td>
<td>1178</td>
<td>1028</td>
<td>890</td>
<td>471</td>
<td>189</td>
<td>39</td>
<td>0</td>
<td>9</td>
<td>105</td>
<td>378</td>
<td>783</td>
<td>1135</td>
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<tr>
<td><strong>HEATING</strong></td>
<td></td>
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<tr>
<td><strong>DEGREE DAYS</strong></td>
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<tr>
<td><strong>NORMAL MO. TEMP.</strong></td>
<td>52.1</td>
<td>29.1</td>
<td>31.1</td>
<td>38.9</td>
<td>50.8</td>
<td>61.4</td>
<td>71.1</td>
<td>75.2</td>
<td>73.7</td>
<td>66.5</td>
<td>55.4</td>
<td>40.9</td>
<td>31.1</td>
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<td><strong>TOTAL DAILY</strong></td>
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<tr>
<td><strong>INSOLATION</strong></td>
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<tr>
<td><strong>VERTICAL</strong></td>
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</tr>
<tr>
<td><strong>AZIMUTH/ALT.</strong></td>
<td>55.3</td>
<td>42.2</td>
<td>49.4</td>
<td>49.3</td>
<td>52.3</td>
<td>49.7</td>
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<td>49.2</td>
<td>49.7</td>
<td>49.1</td>
<td>49.2</td>
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<tr>
<td><strong>8-4</strong></td>
<td></td>
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<td><strong>AZIMUTH/ALT.</strong></td>
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<td><strong>AZIMUTH/ALT.</strong></td>
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<tr>
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<td>20.0</td>
<td>20.0</td>
<td>20.0</td>
<td>20.0</td>
</tr>
</tbody>
</table>

**data**
preliminary design
THE DESIGN IS BASED ON THESE:

A) MAXIMUM USAGE OF PASSIVE HEAT
   SOLAR IVALL
   TROMBE IVALL

B) DIFFERENT HEATING REQUIREMENTS
   NIGHT (HEAT SINK) (THERMAL LAG)
   DAY (DIRECT)

C) ORIENTATIONS OF THE SUN THROUGHOUT THE YEAR

   SUMMER - HIGH ALTITUDE
     WIDE AZIMUTH

   WINTER - LOW ALTITUDE
     NARROW AZIMUTH
DESIGN

IN THIS DESIGN THESE CONCEPTS ARE USED:

SOUTHERN SOLAR WALLS -
- Collect morning and afternoon sun
- Warms house during daytime
- Direct solar heat
- Shutters over windows at night

TROMBE WALL
- Warms air during daytime
- Wall acts as a heat sink
- Warms night areas — thermal lag
- Indirect solar heat
- Vents closed at night to prevent heat loss

SEPARATION OF AREAS
- Night areas receiving late afternoon exposure (S.W.)
- Day areas receiving morning & day exposure (warm house early & throughout the day)

BACK-UP SYSTEM
- Heat pump used
- Fireplace
SUMMER SUNLIGHT FROM S.W.

WINTER SUNLIGHT FROM S.W.

TROMBE WALL

AREAS TO BE HEATED AT NIGHT

schematic
HEAT LOSS UNDERGROUND

\[ (d_1 \times (\text{insulative value of dirt})) \]

R VALUES

WALL 2 (SOLAR) 23'10" x 9'
- CRYSTAL GLASS
- WOOP
- STYROFOAM 1"

OUTSIDE AIR FILM
- .17

CRYSTAL GLASS 1.45

SHUTTERS 1.56

WALL 3 (STROMBE) 18'10" x 9'
- GLASS
- 12" CONCRETE (.08/\text{in})
- 1" STYROFOAM

R \text{ total} = 7.67
# Building as a Heat Trap

## Heat Loss Calculations

1. **Design Temperature \( \Delta t \)**
   - Underground: 50° \( \Delta t = 15^\circ \)
   - Above: -20° \( \Delta t = 45^\circ \)

2. **Heat Loss \( \text{BTU's/HR.} \)**

<table>
<thead>
<tr>
<th>Area</th>
<th>Sq. Ft.</th>
<th>BTU/ft²/HR</th>
<th>Heat Loss BTU/HR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Below</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floor</td>
<td>1340</td>
<td>2.0</td>
<td>2680</td>
</tr>
<tr>
<td>Ceiling</td>
<td>1340</td>
<td>1.32</td>
<td>1769</td>
</tr>
<tr>
<td>Wall 1</td>
<td>1000</td>
<td>4.4</td>
<td>4400</td>
</tr>
<tr>
<td><strong>Above</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar Wall (Wall 2)</td>
<td>2520</td>
<td>.1344</td>
<td>45°</td>
</tr>
<tr>
<td>Trombe (Wall 3)</td>
<td>224</td>
<td>.1304</td>
<td>45°</td>
</tr>
</tbody>
</table>

**Total** | 11,711.7 |
(3) Daily Loss = 281,081.5 \text{ Btu's} \\
\text{\underline{.28 MBtu's}}

(4) Heat Loss Per Degree Day

Below 
\[ 8849 \times 24 \text{ Hr.} = \frac{212,376}{150} = 14,158.4 \]

Above 
\[ 2862.7 \times 24 \text{ Hr.} = \frac{68,105}{450} = 1526.8 \]

Total \[ \underline{15,685.2} \]
<table>
<thead>
<tr>
<th></th>
<th>Y</th>
<th>j</th>
<th>f</th>
<th>m</th>
<th>a</th>
<th>m</th>
<th>j</th>
<th>j</th>
<th>a</th>
<th>s</th>
<th>o</th>
<th>n</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td># DAYS/MO.</td>
<td>365</td>
<td>31</td>
<td>28</td>
<td>31</td>
<td>30</td>
<td>31</td>
<td>30</td>
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<td>31</td>
<td>30</td>
<td>31</td>
<td>30</td>
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<tr>
<td>DEGREE DAYS</td>
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<td>890</td>
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<td>.0044</td>
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heating load
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<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
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<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
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<td>1730</td>
<td>1984</td>
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<td>Trombe wall</td>
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**solar gain**
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<th>DEC. 21</th>
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<td>221</td>
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<td>252</td>
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<td>163</td>
<td>56</td>
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<td>8205</td>
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<td>3937</td>
<td>36720</td>
<td>39520</td>
<td>36720</td>
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<td>8205</td>
<td>1001</td>
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<td>120 ft trombe (41 types)</td>
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<td>36720</td>
<td>39520</td>
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<td>8205</td>
<td>2348</td>
<td>3937</td>
<td>36720</td>
<td>39520</td>
<td>36720</td>
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<td>2348</td>
<td>8205</td>
<td>1001</td>
<td>5581</td>
<td>4774</td>
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</table>

**Graphs:**
- **Collected Insolation**
- **Heat Loss**
- **Auxiliary System**

**Daily Loss/Gain**
DAILY HEAT LOSS/GAIN COMPARISON

The previous chart shows the comparison of heat loss to solar heat gain on Dec. 21. The actual effects of the Trombe wall aren't fully represented by the graph, the heat would be released gradually from the wall.

Heat loss could further be reduced by additional insulation.

Separation of night & day areas & heat released during those hours would be most efficient.
MONTHLY HEAT LOSS/GAIN COMPARISON

The previous chart illustrates the comparison of heat loss to solar heat gain throughout the entire year. It follows fairly closely the same curve, the only overlap occurring June through November.

This relationship can be improved by the following adjustments:
- Additional shading June thru November (late summer)
- Additional insulation
  - Shutter units
  - Underground walls, etc.
design development
IMAGE SKETCH OF CENTRAL GREEN/PARK AREA
DEVELOPMENT OF UNIT

1. Unit concept
   - South (focus) terrace
   - Private, open
   - Door, open-camped
   - View to valley or enclosed space

2. Diagrams of floor plans

3. Plan of building

4. Plan of building

---

- Diagram notes: south focus terrace, private open areas, door opening.
DEVELOPMENT OF COURTYARD

- Entrance to units at corner not visible at entry to courtyard
- Canopy
- Pedestrian areas
- Trees
- Parking
- Post trees (circles)