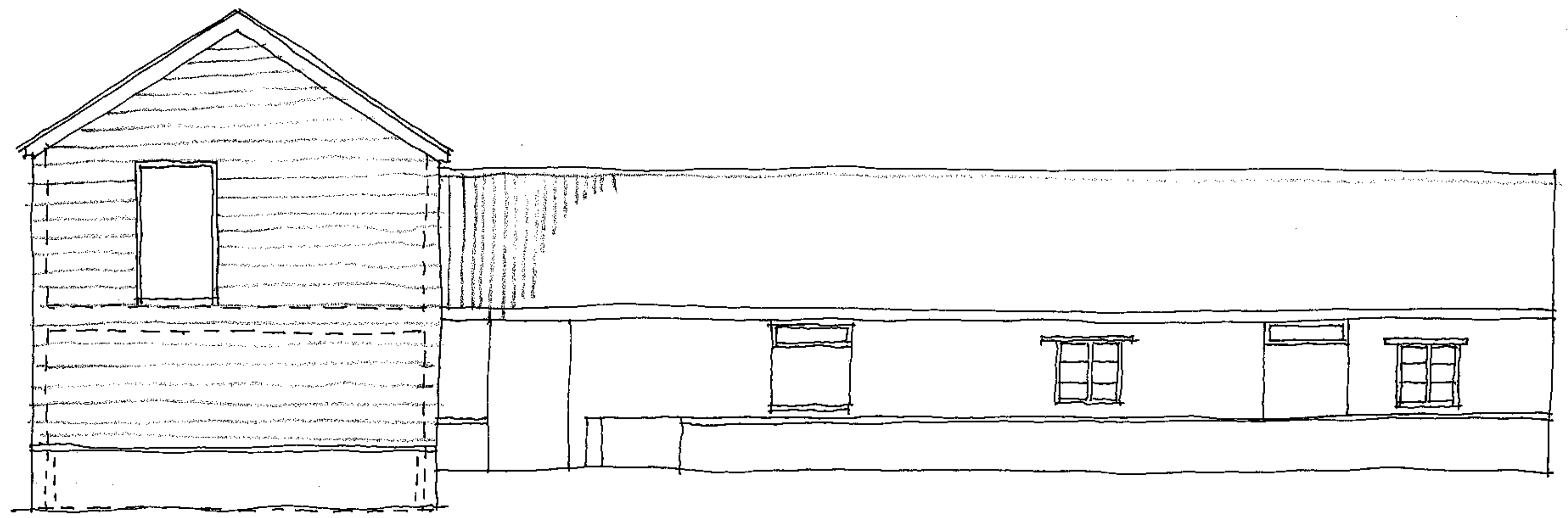
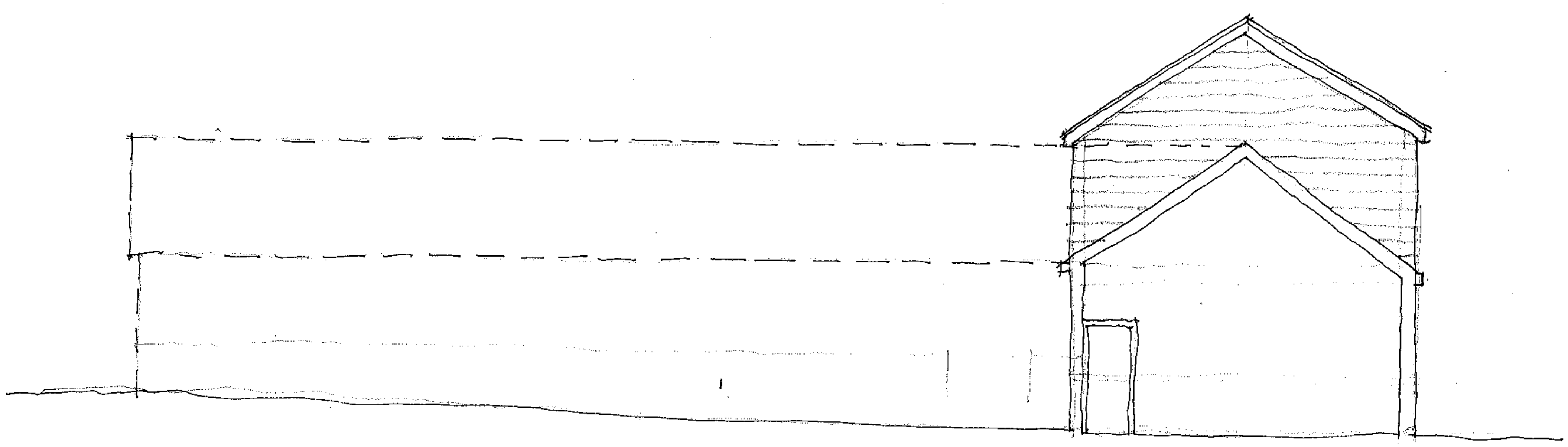
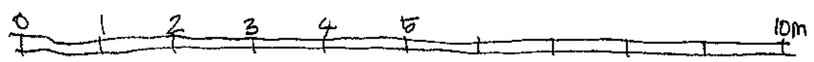


SOUTH ELEVATION. 1:100

100.



NORTH ELEVATION.

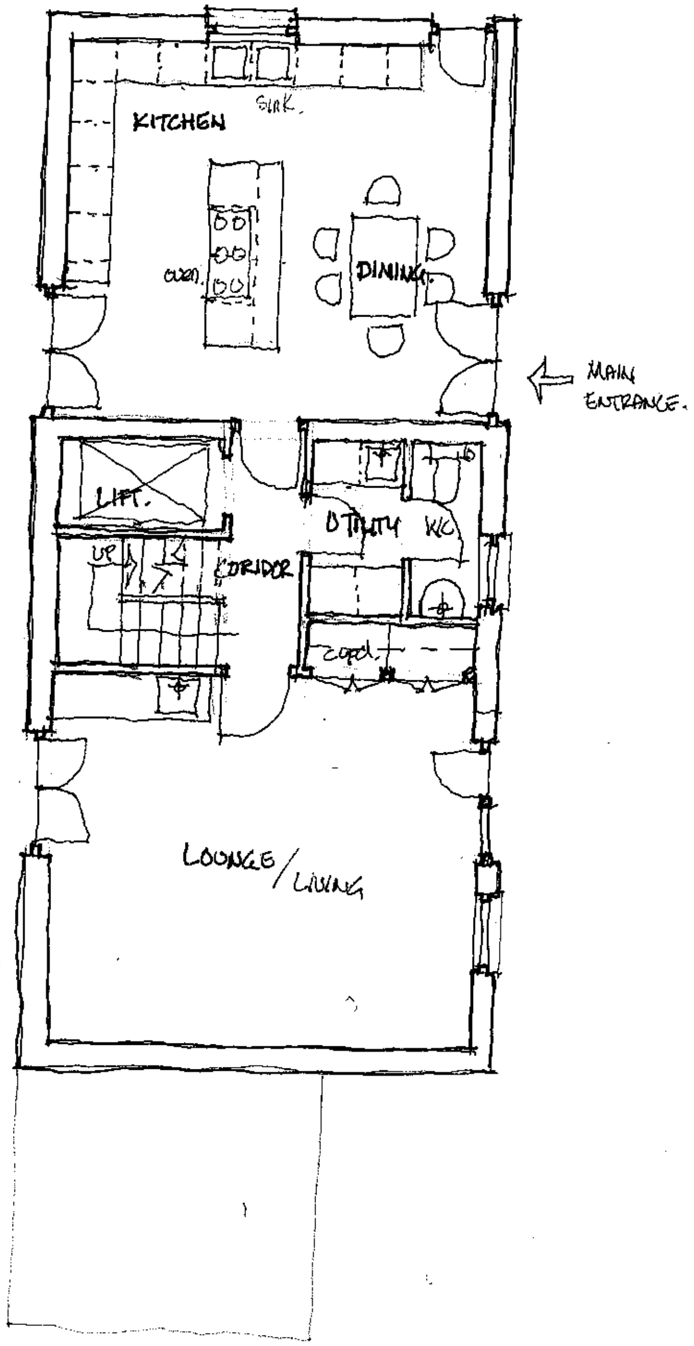


GREENYARD FARM. ST ANDREWS MAJOR

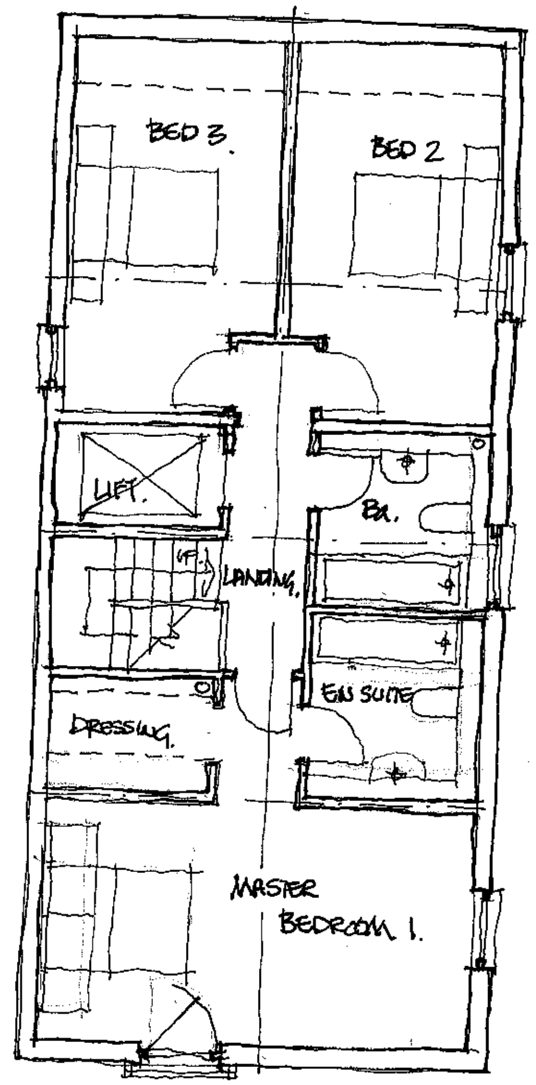
EXISTING BARN B.

DESIGNCELL ARCHITECTURE LTD

PR/B/31



GROUND FLOOR PLAN 1:100



FIRST FLOOR PLAN. 1:100

NORTH

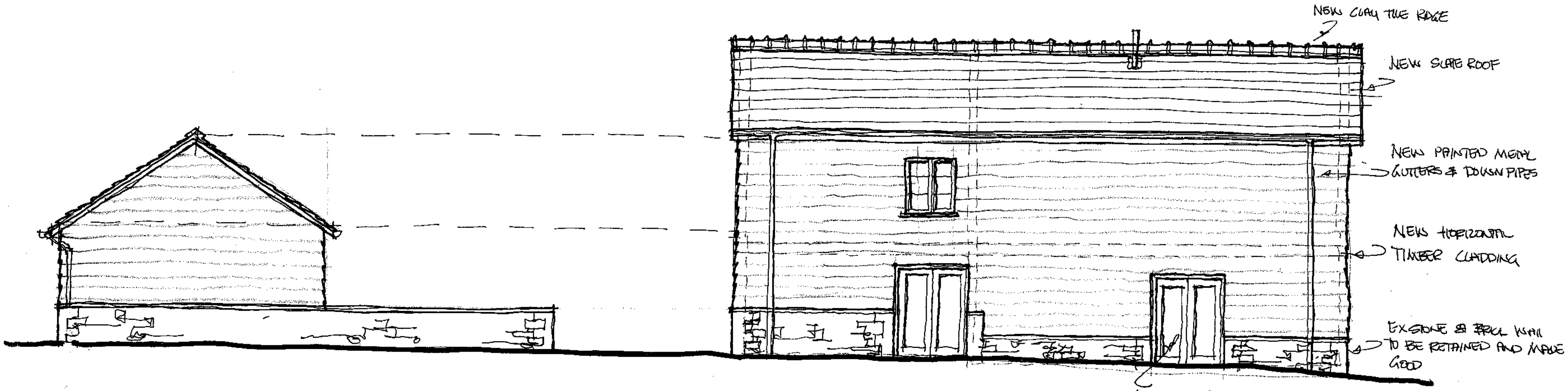
0 1 2 3 4 5 10m

GREENYARD FARM. ST ANDREWS MAJOR

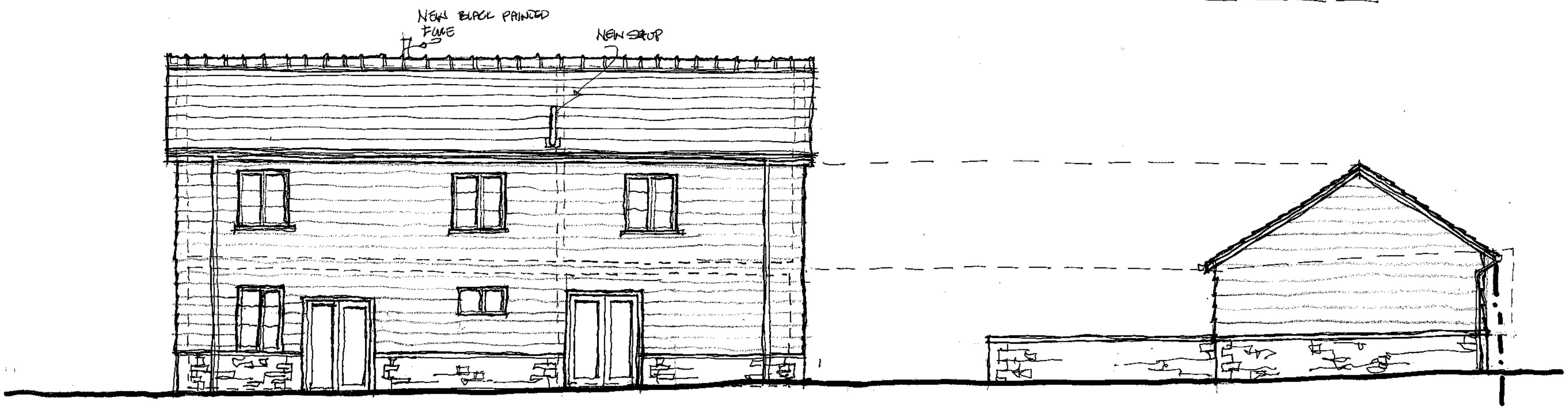
PROPOSED BARN B.

DESIGNCELL ARCHITECTURE LTD.

PR/B/32



WEST ELEVATION 1:100

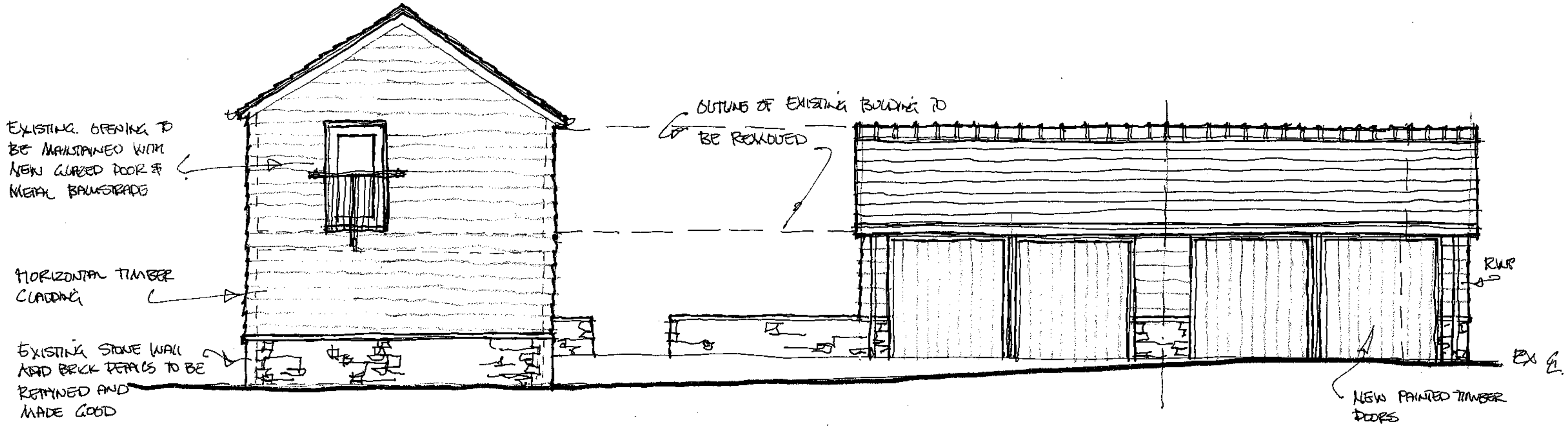


EAST ELEVATION 1:100

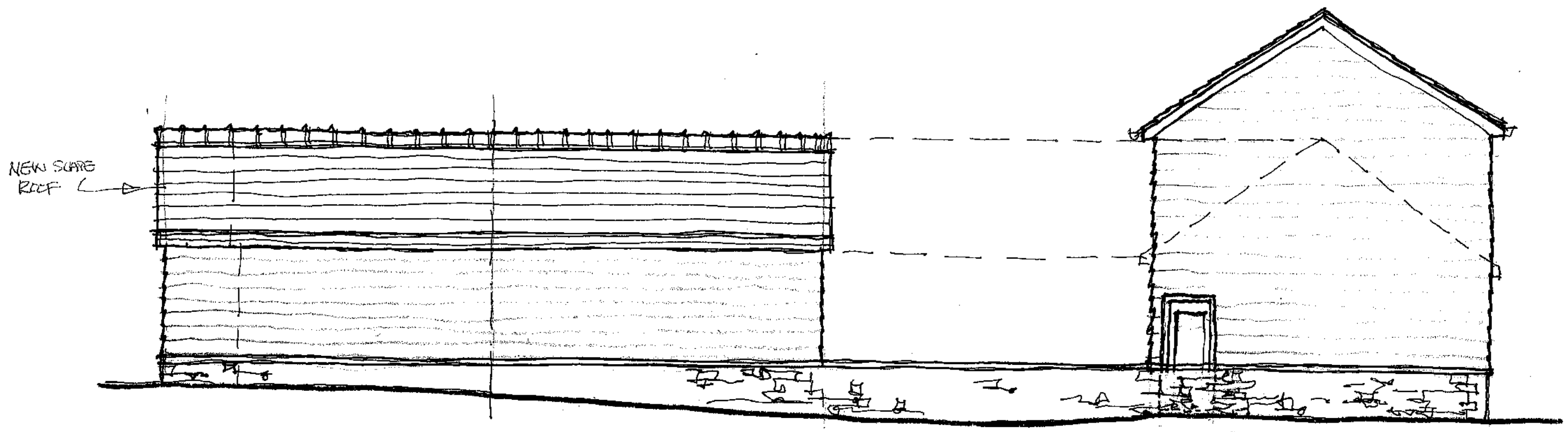
100

0 1 2 3 4 5 10m

GREENYARD FARM. ST ANDREWS MAJOR. | PROPOSED BARN B. | DESIGNCELL ARCHITECTURE LTD



SOUTH ELEVATION 1:100.



NORTH ELEVATION.

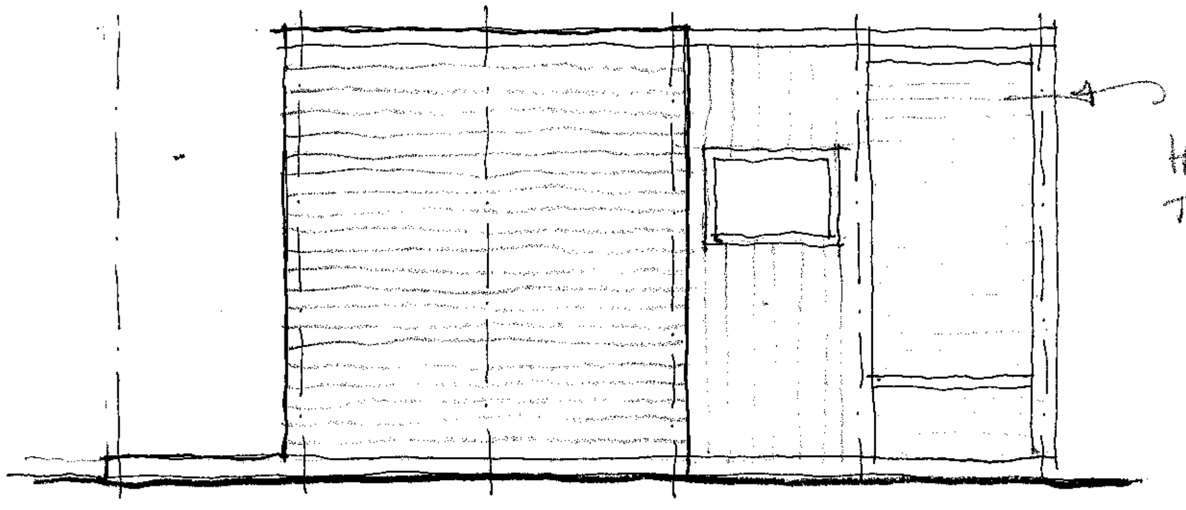
0 1 2 3 4 5 10m

GREENYARD FARM ST ANDREWS MAJOR

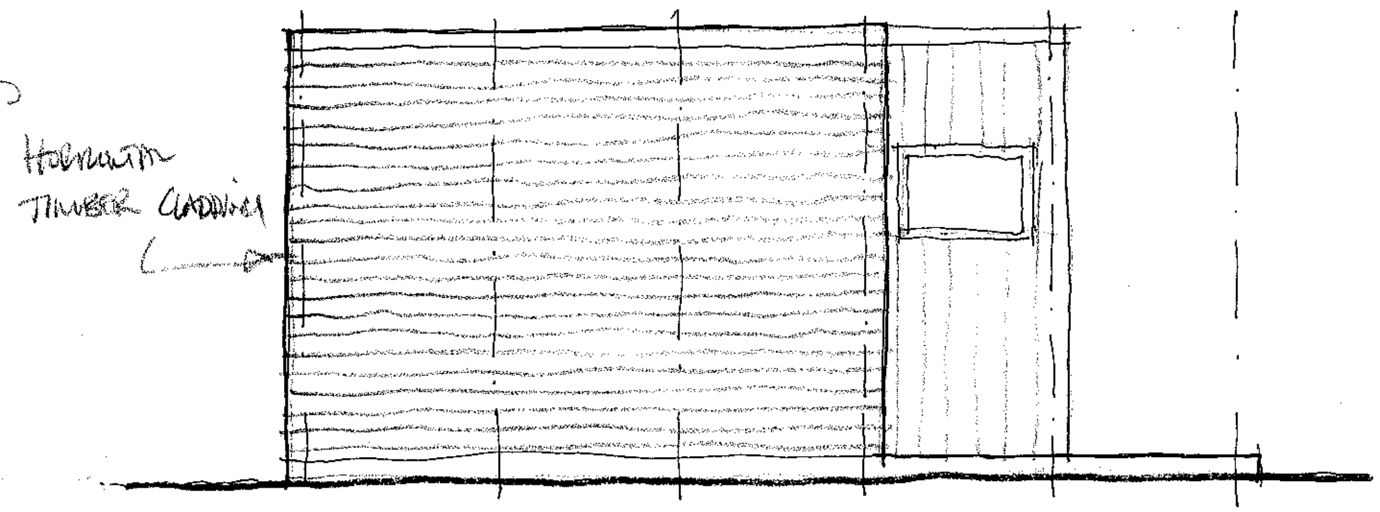
PROPOSED BARN B.

DESIGNCELL ARCHITECTURE LTD

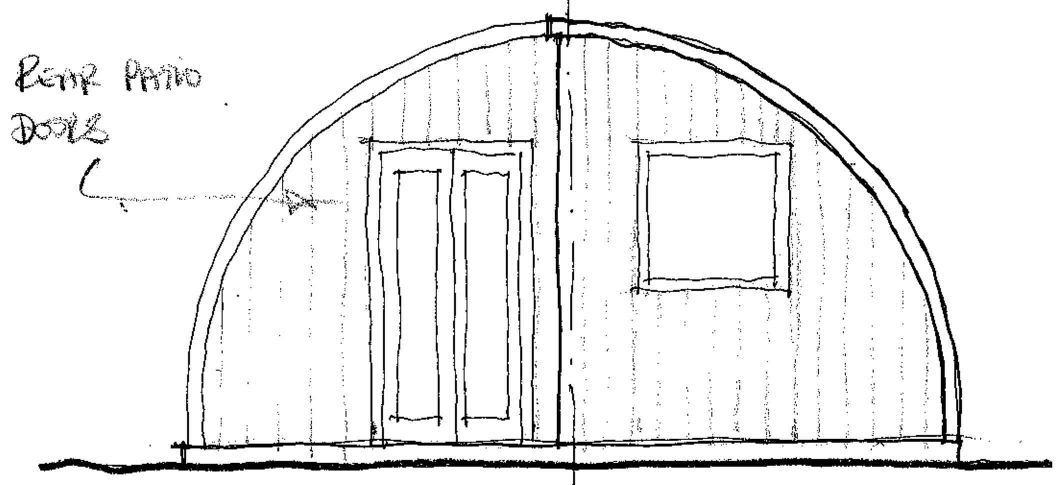
UNIT A. 4 PERSON.



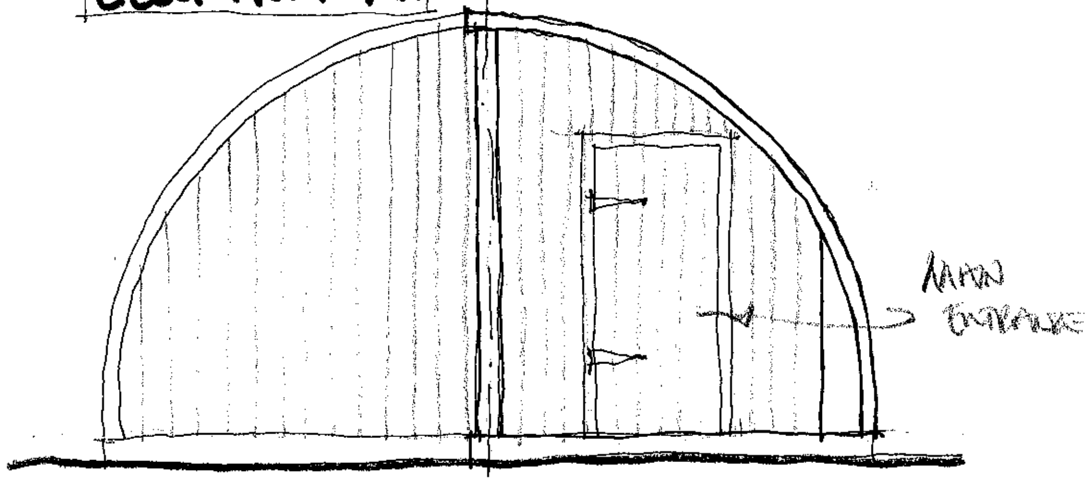
ELEVATION C. 1:50



ELEVATION D. 1:50

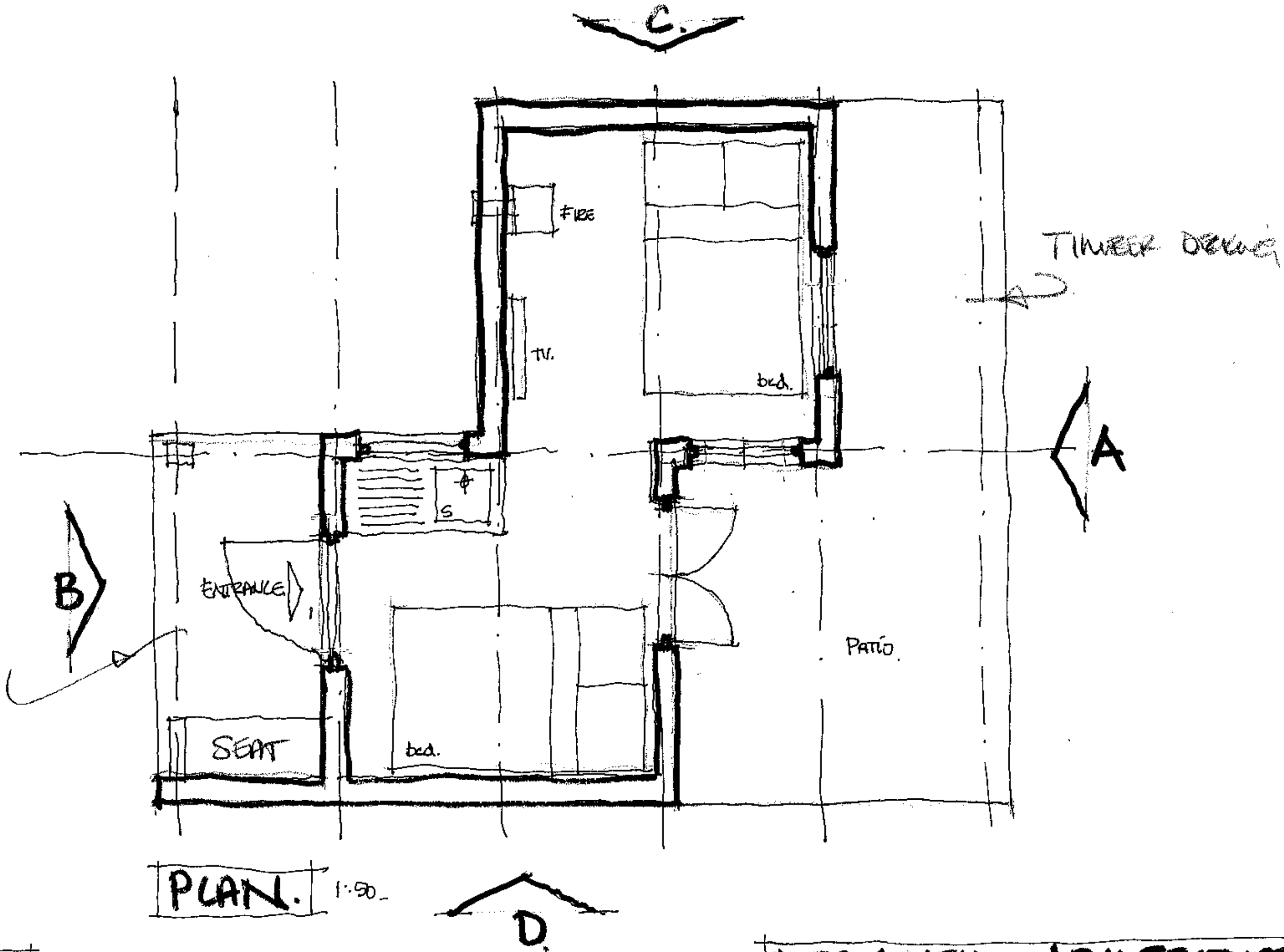


ELEVATION A. 1:50



ELEVATION B. 1:50.

0 1 2 3 4 5m.

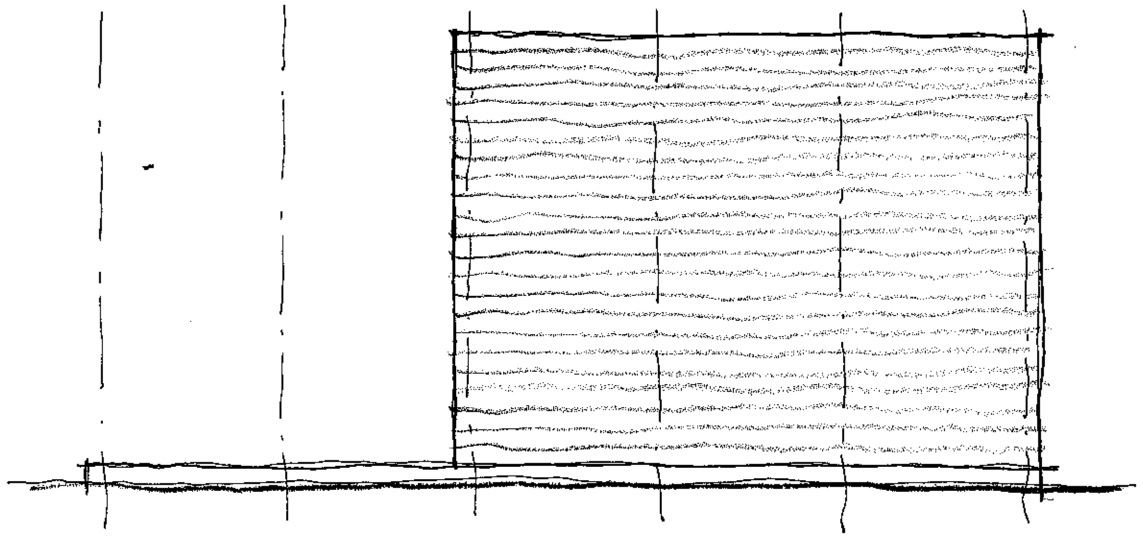


PLAN. 1:50

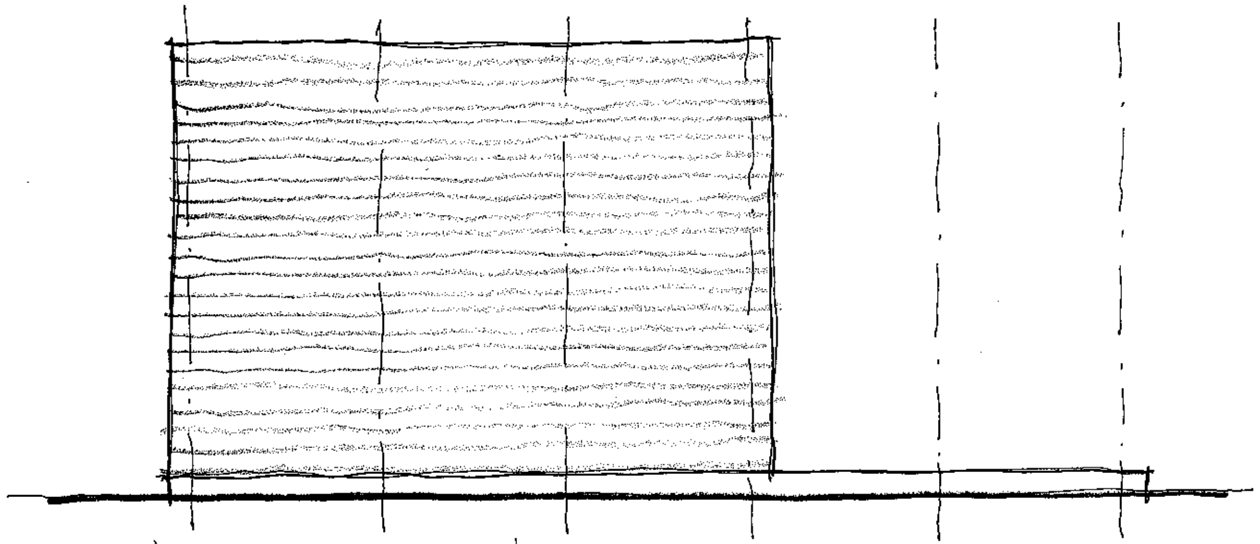
GREENYARD FARM ST ANDREWS MAJOR

DESIGNCELL ARCHITECTURE LTD

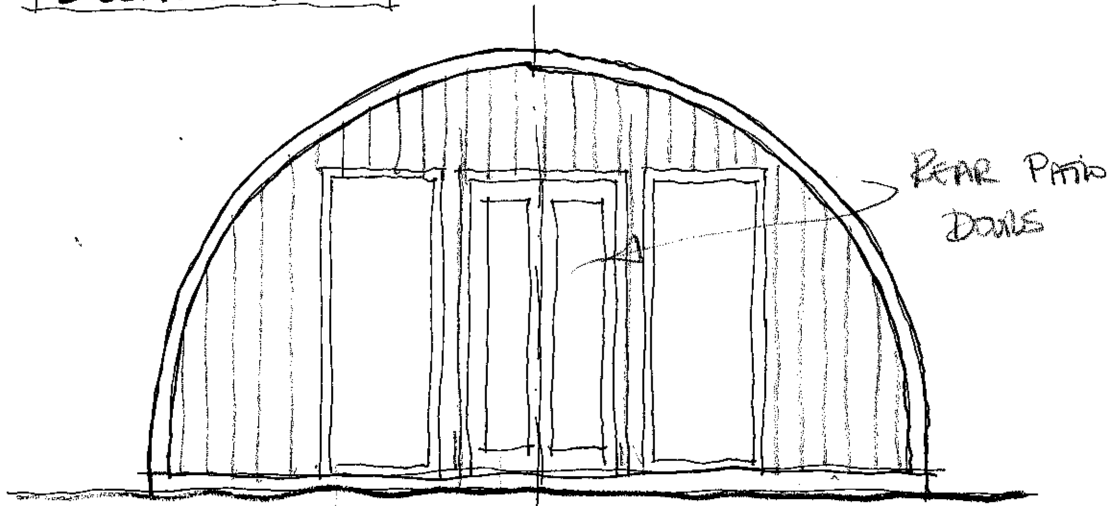
UNIT B. 6 PERSON.



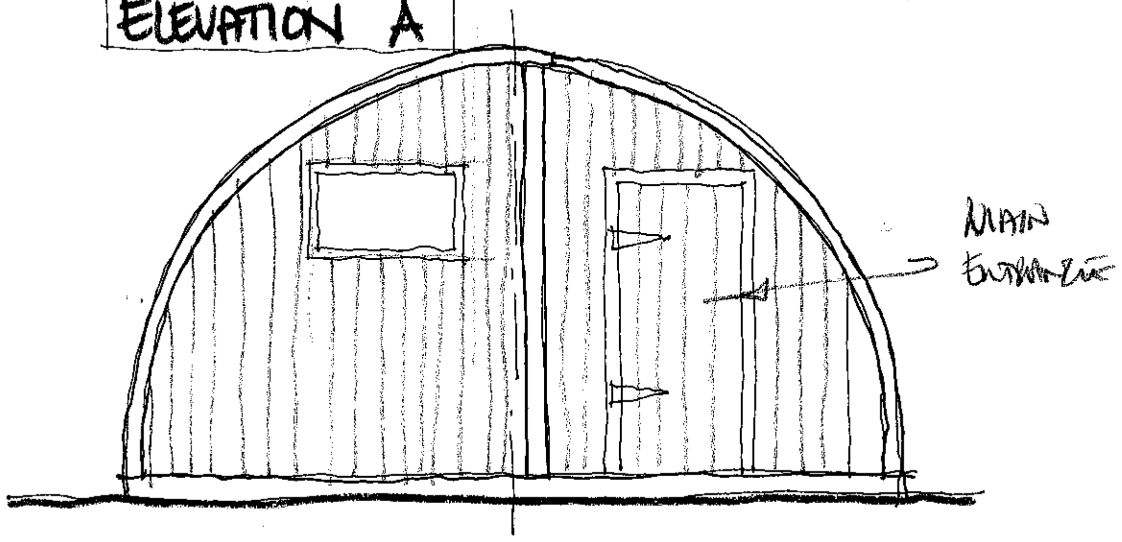
ELEVATION C



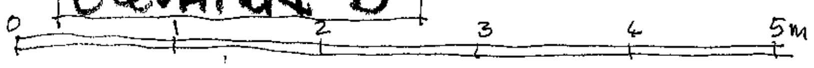
ELEVATION D

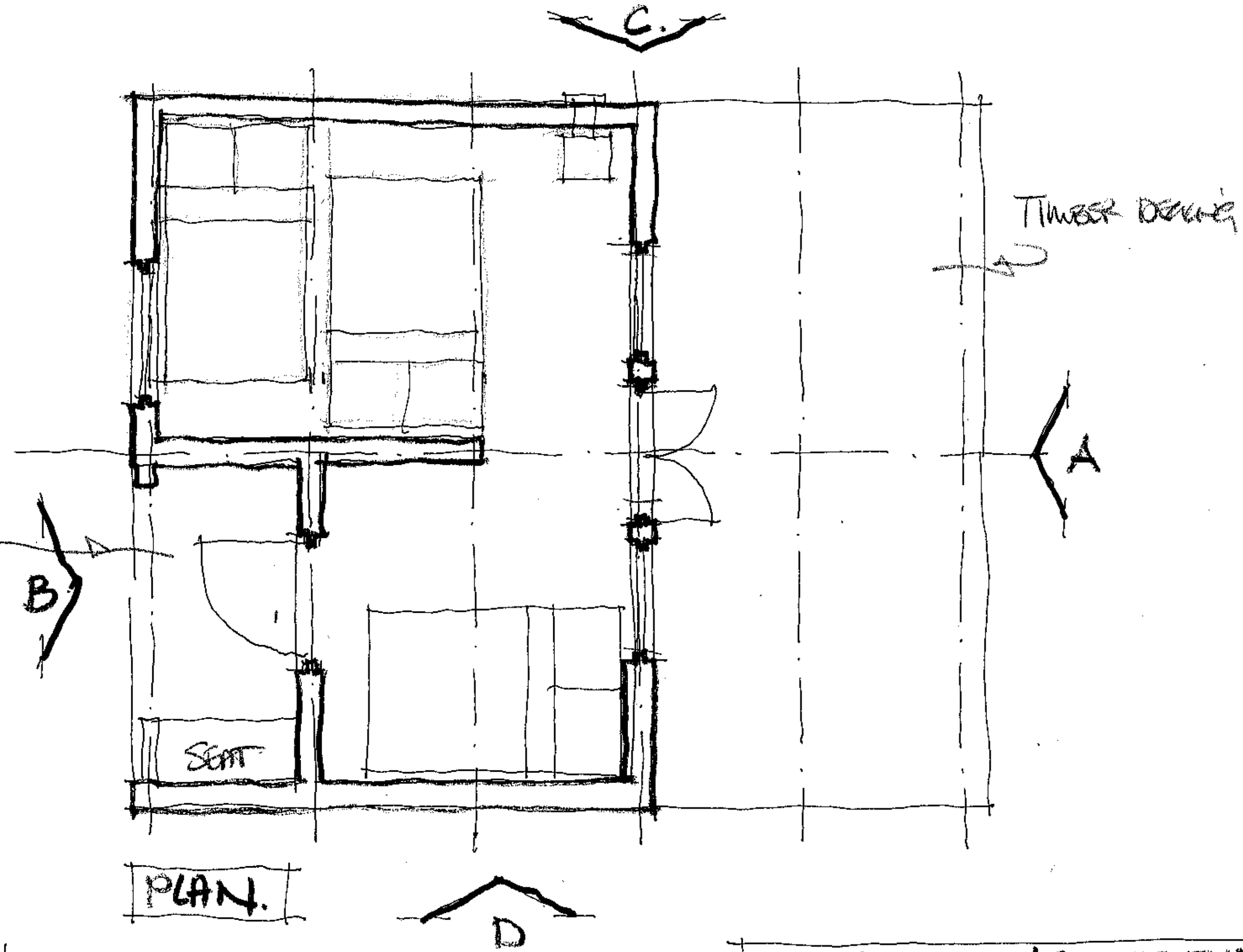


ELEVATION A



ELEVATION B



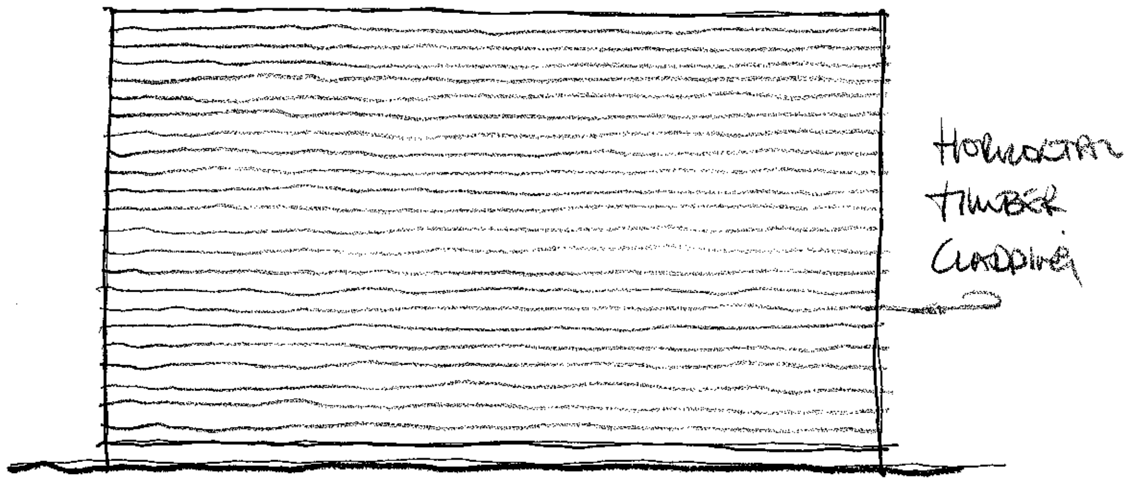


PLAN.

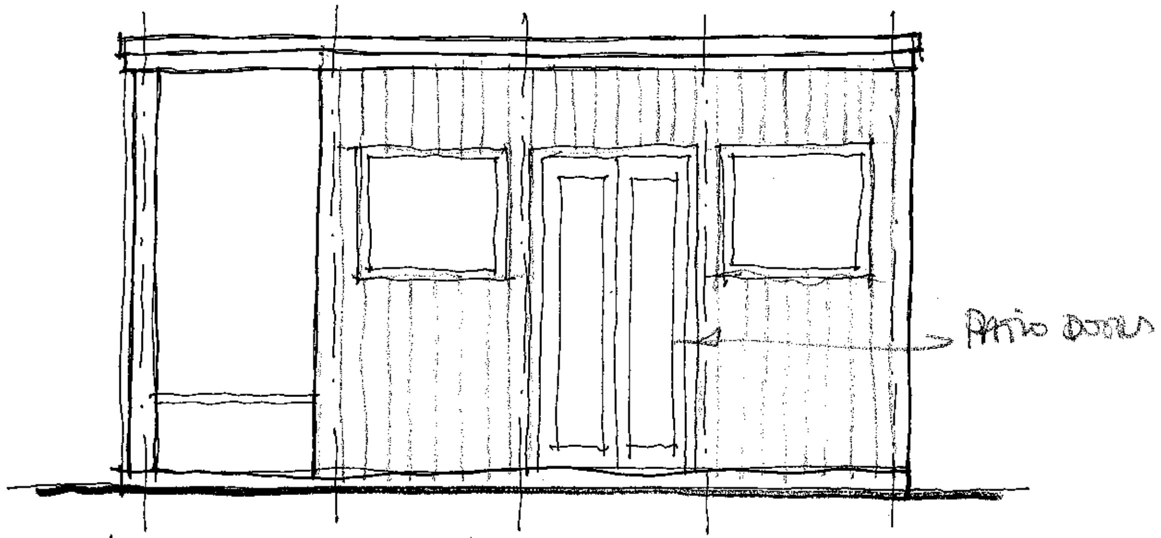
GREENYARD FARM ST ANDREWS MAJOR

DESIGNCELL ARCHITECTURE LTD.

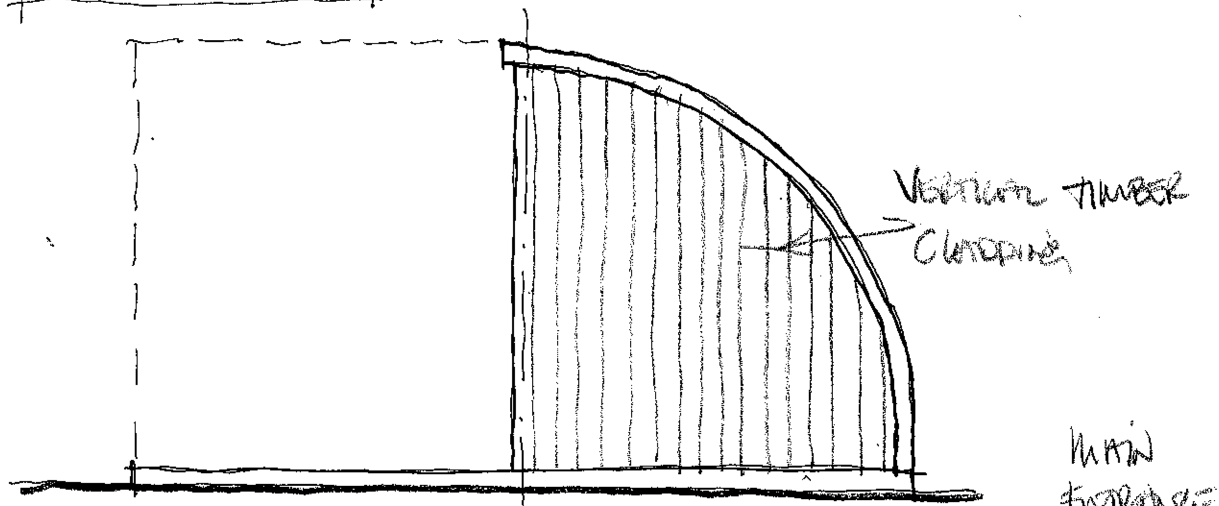
UNIT C. 4 PERSON



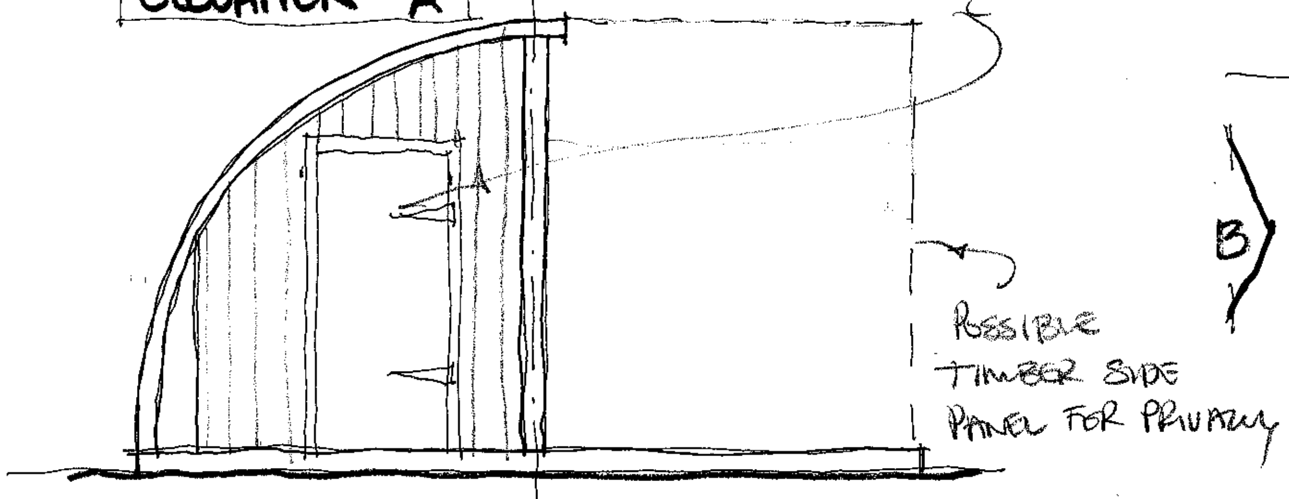
ELEVATION C.



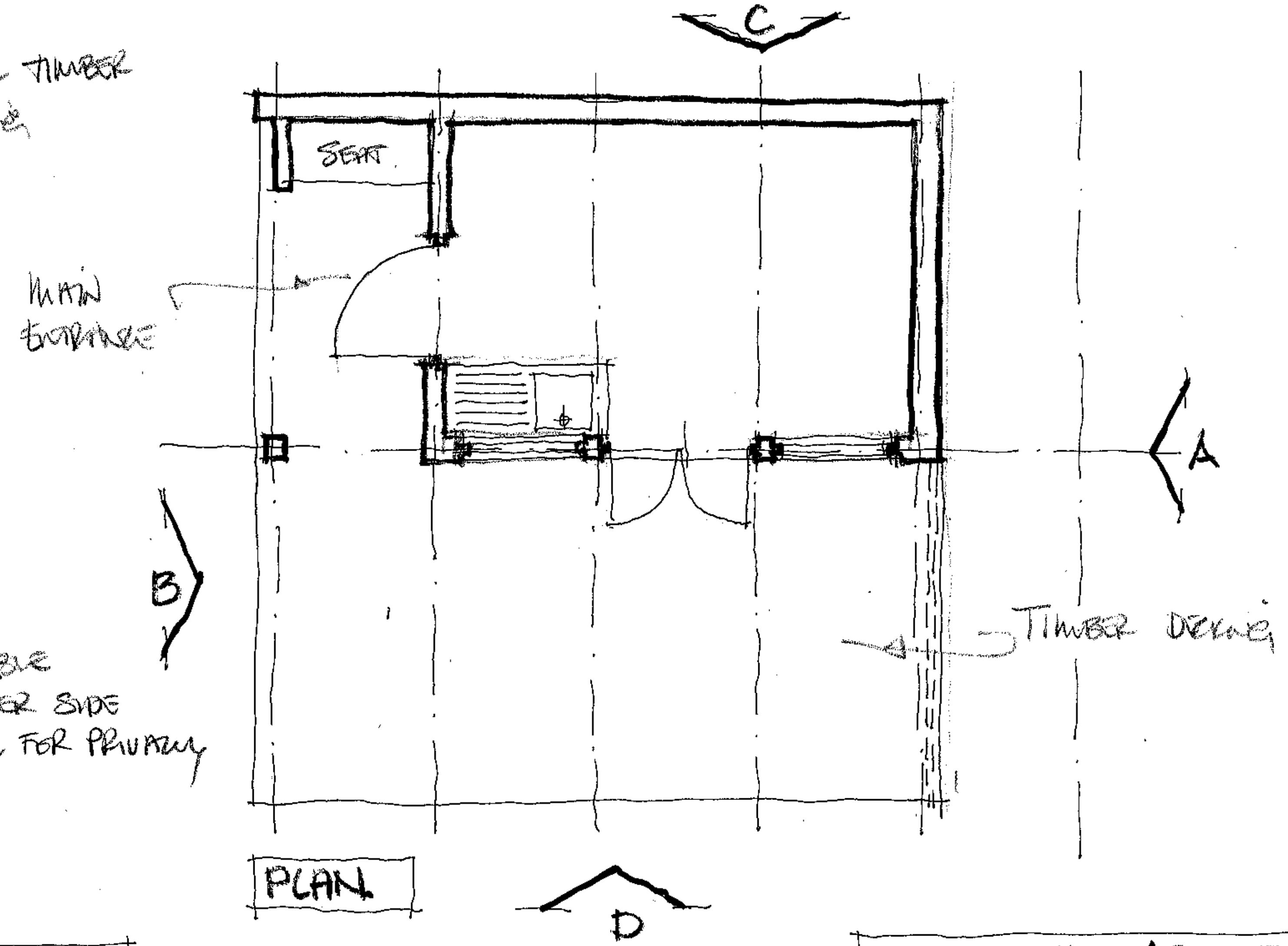
ELEVATION D



ELEVATION A



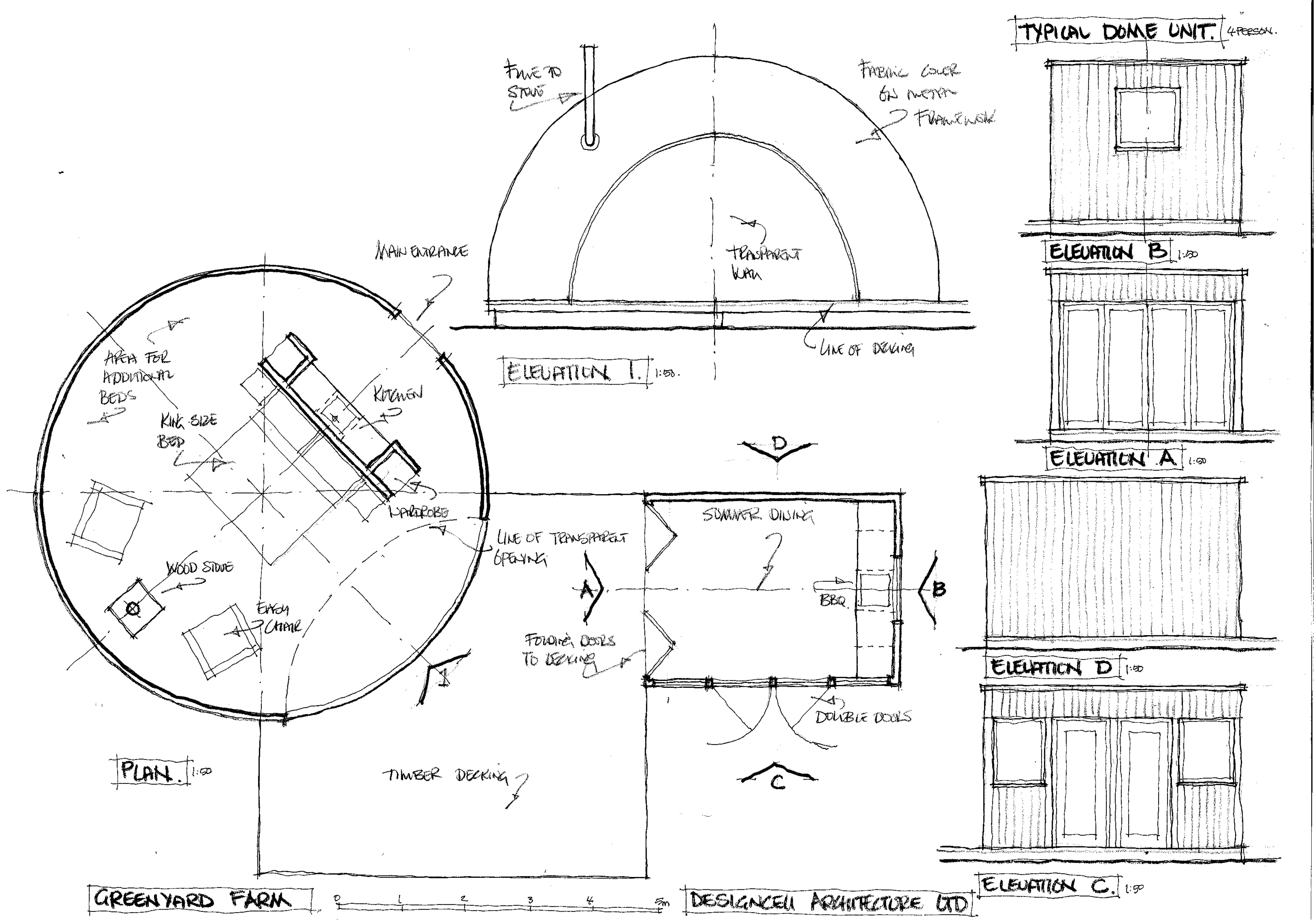
ELEVATION B



PLAN.

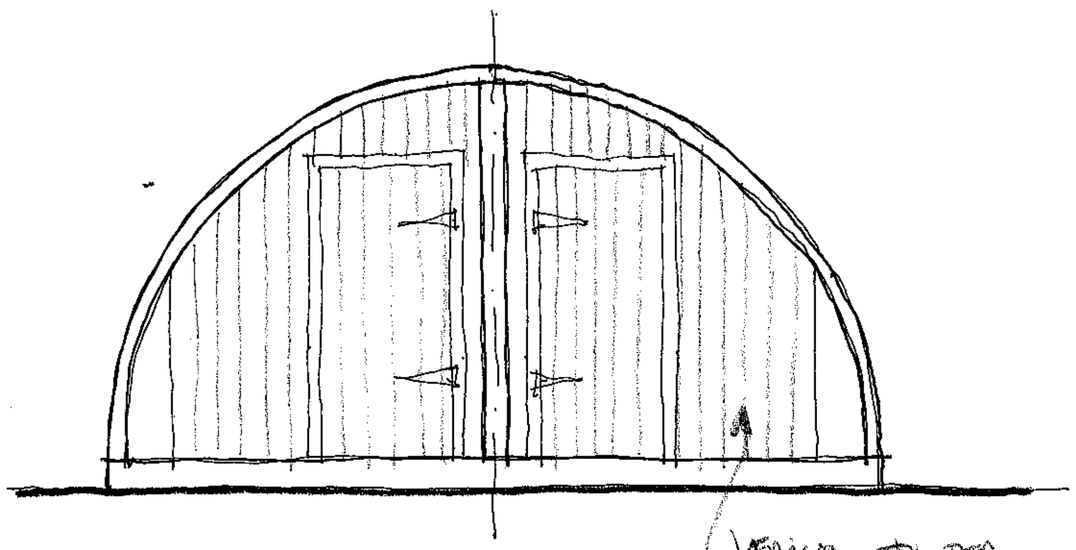
GREENYARD FARM ST ANDREWS MAJOR

DESIGNCELL ARCHITECTURE LTD.

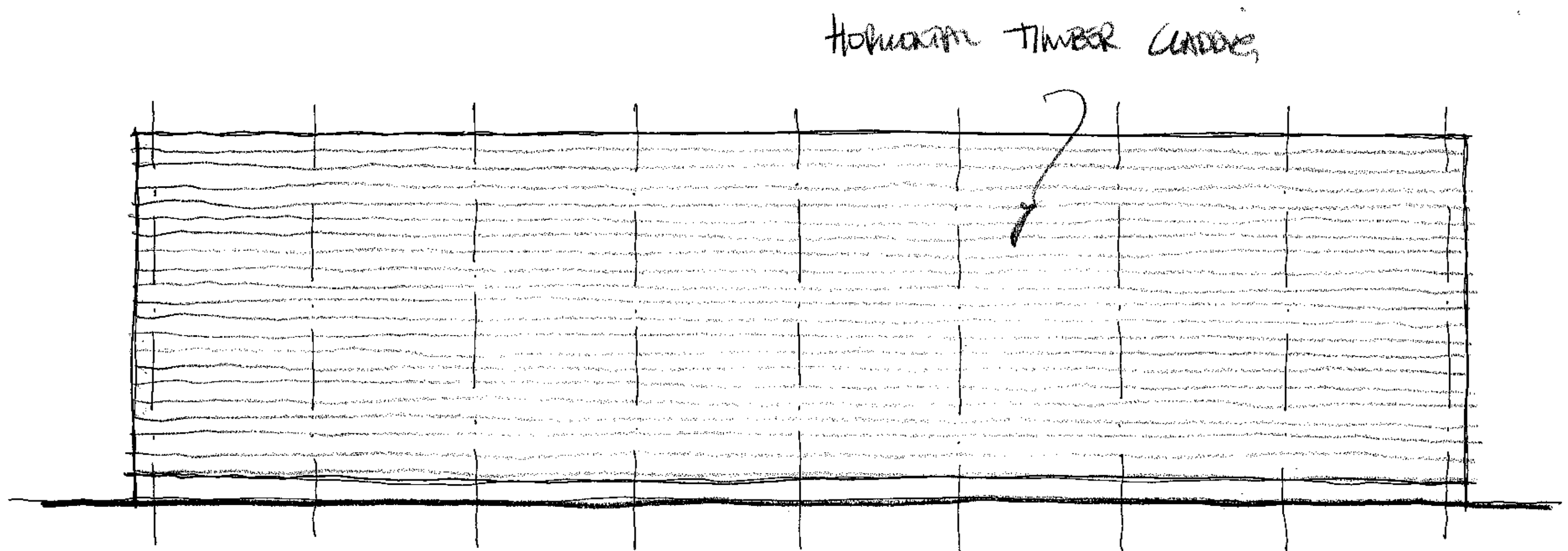


TYPICAL DOME UNIT. 4 PERSON.
FLUE TO STOVE
FABRIC COLOR ON METAL FRAMEWORK
TRANSPARENT WALL
MAIN ENTRANCE
LINE OF DECKING
ELEVATION 1. 1:50.
ELEVATION B 1:50
ELEVATION A 1:50
ELEVATION D 1:50
ELEVATION C. 1:50
AREA FOR ADDITIONAL BEDS
KING SIZE BED
KITCHEN
WARDROBE
LINE OF TRANSPARENT OPENING
WOOD STOVE
EASY CHAIR
SUMMER DINING
BBQ
FOLDING DOORS TO DECKING
DOUBLE DOORS
TIMBER DECKING
A
B
C
D
PLAN. 1:50
GREENYARD FARM
0
1
2
3
4
5m
DESIGNCELL ARCHITECTURE LTD

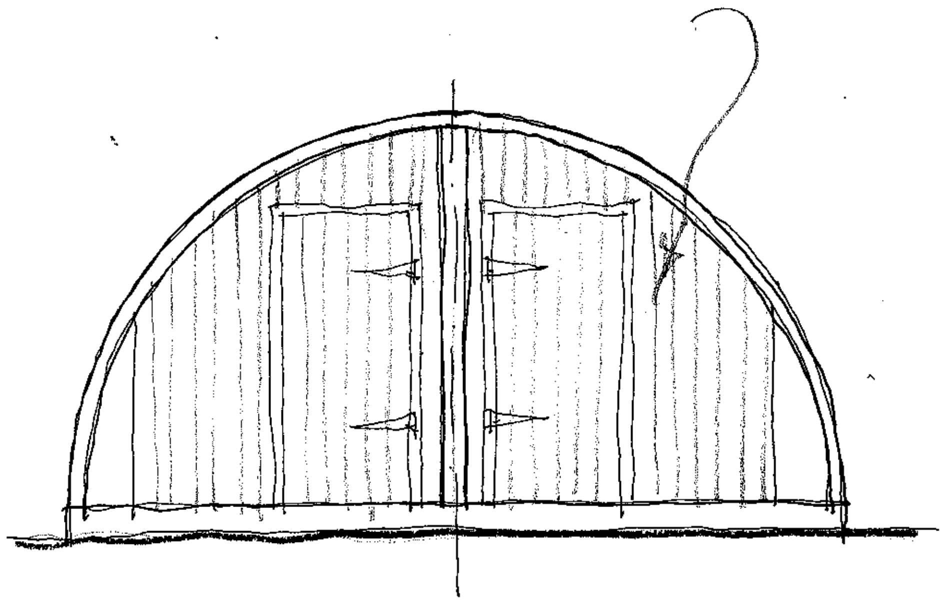
SHOWER UNIT



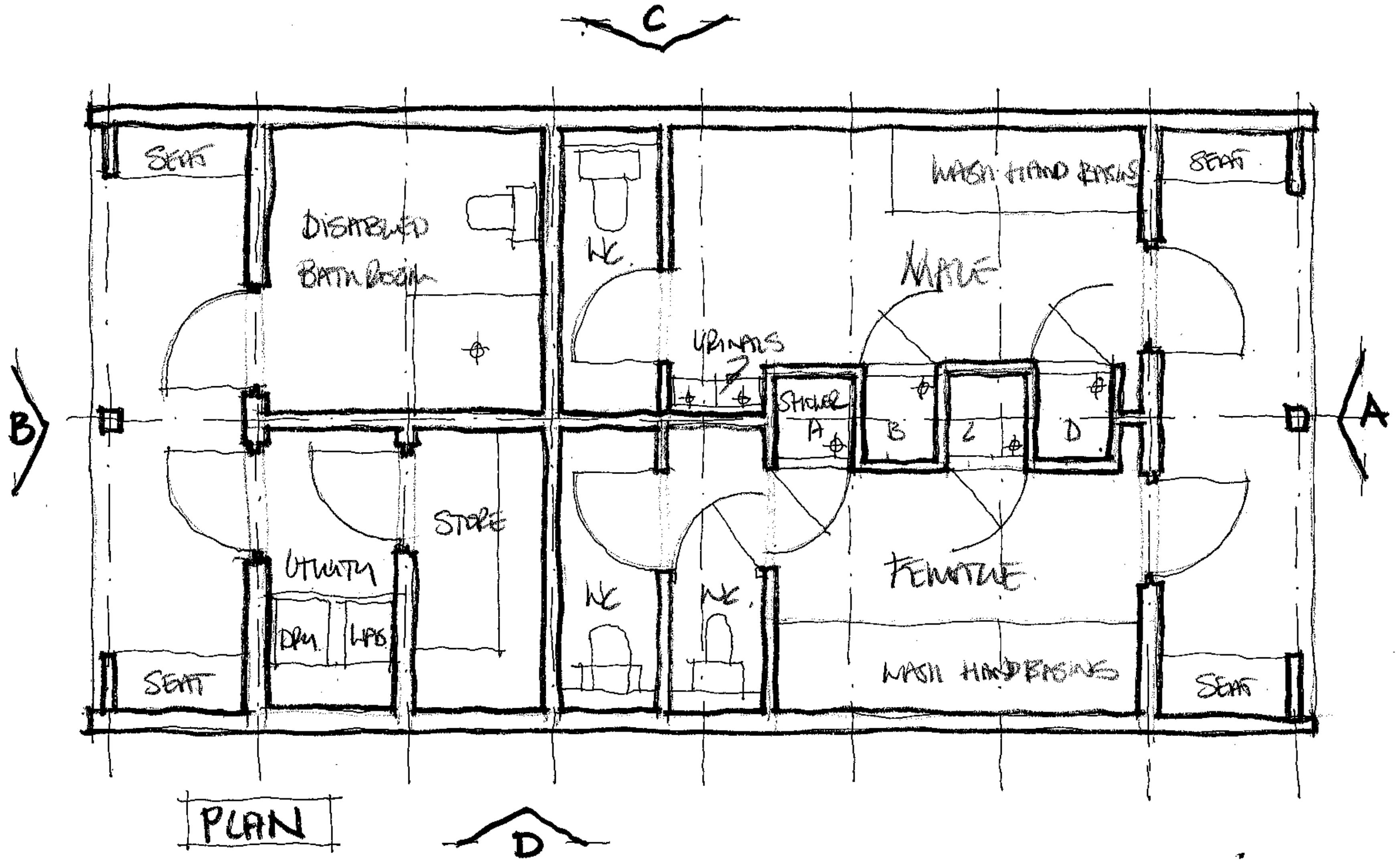
ELEVATION A



ELEVATION C/D



ELEVATION B



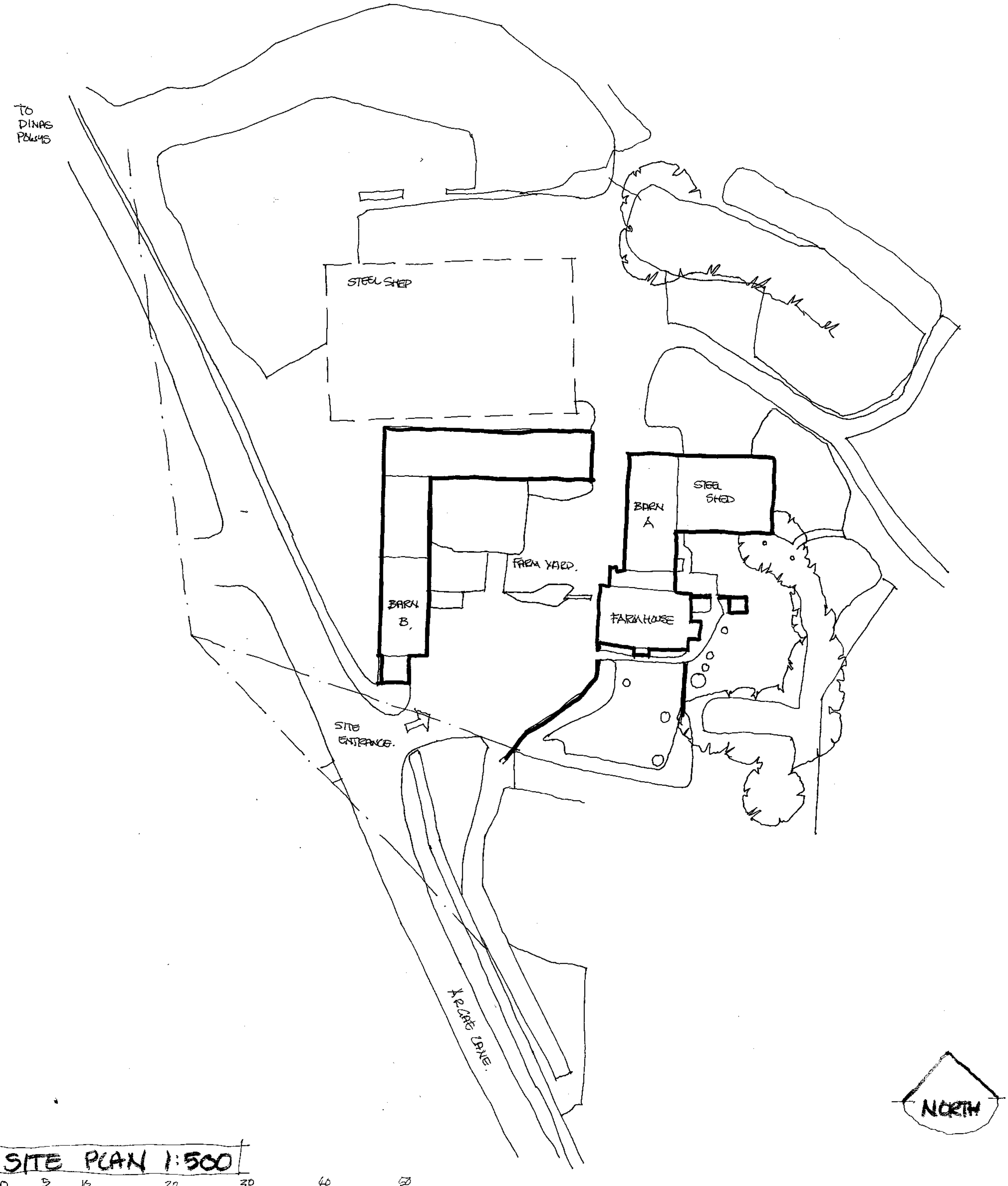
PLAN

0 1 2 3 4 5m

GREENYARD FARM ST ANDREWS MAJOR

DESIGNCELL ARCHITECTURE LTD

EX/SL/20



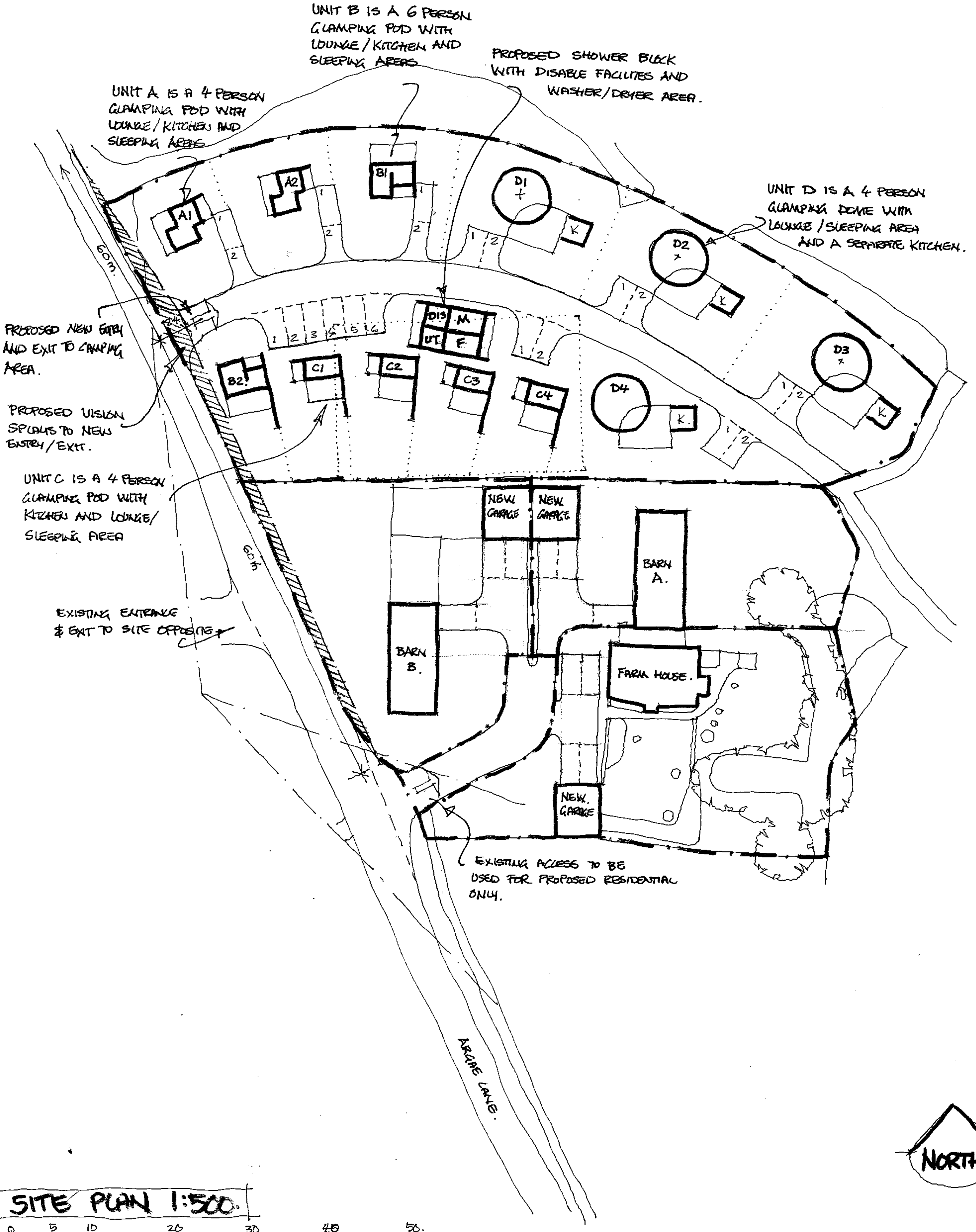
SITE PLAN 1:500

0 5 10 20 30 40 50

GREENYARD FARM

DESIGNCELL ARCHITECTURE LTD

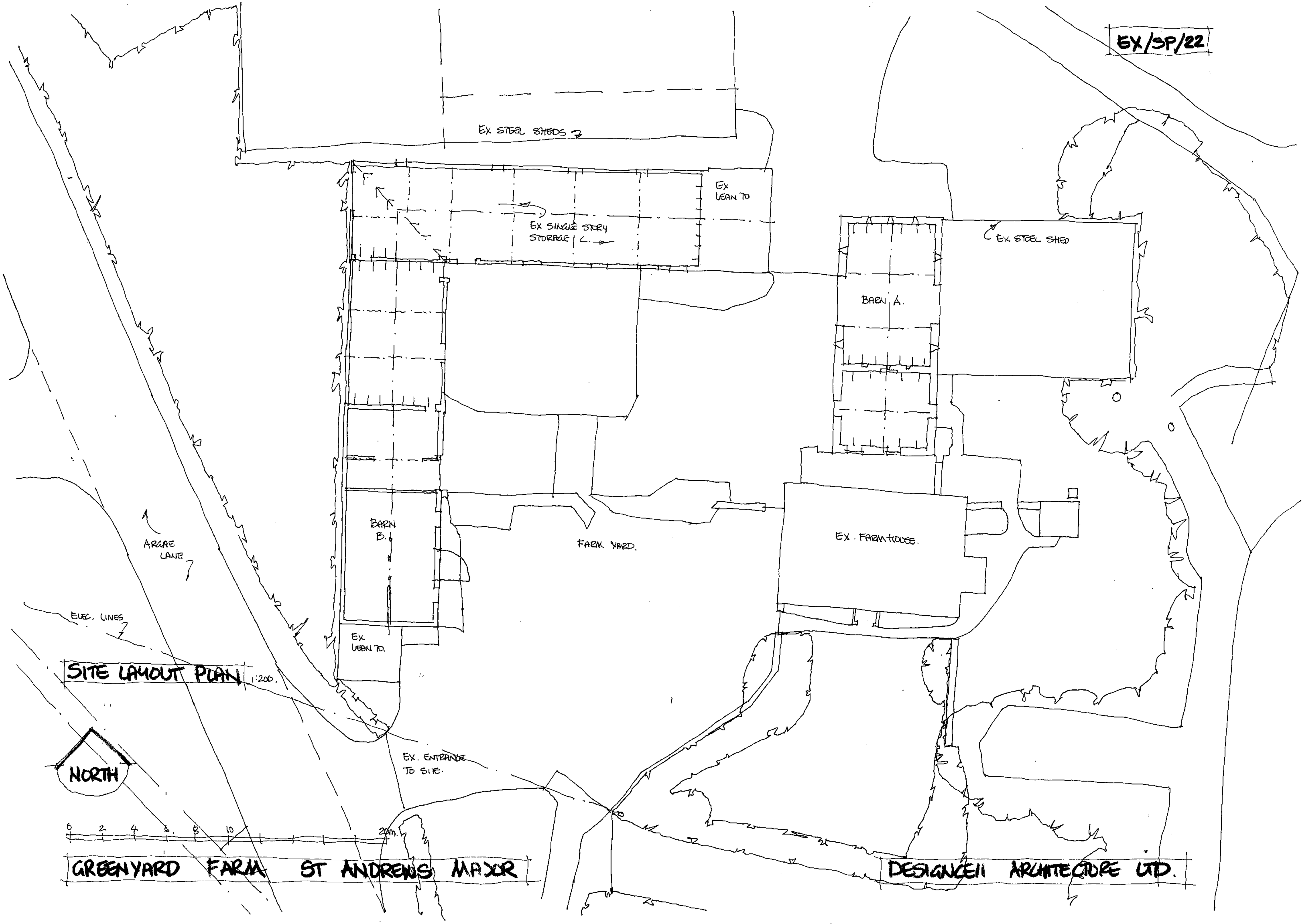
PR/SL/21

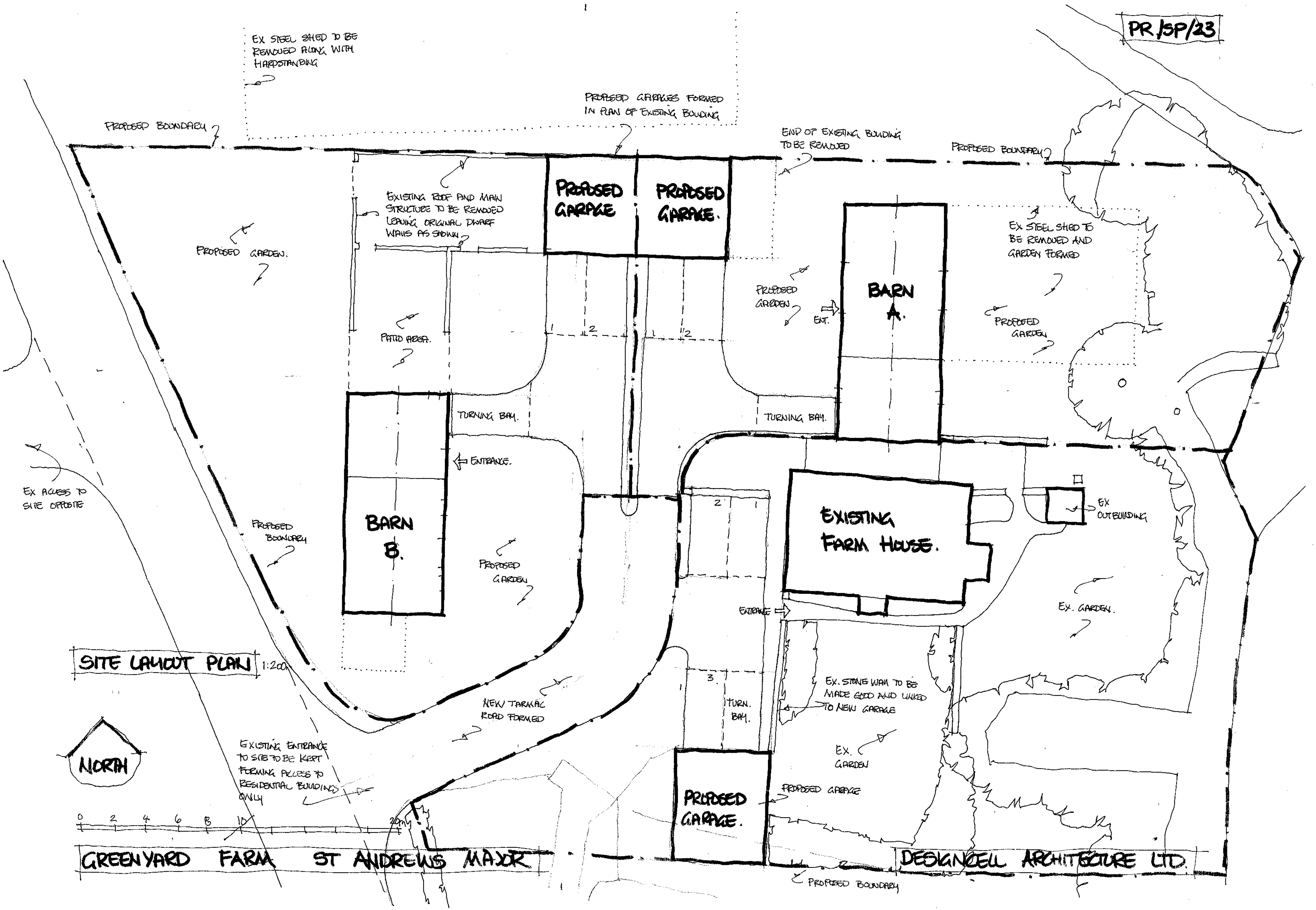


SITE PLAN 1:500.

GREENYARD FARM

DESIGNCELL ARCHITECTURE LTD.


EX/SP/22
EX STEEL SHEDS
EX LEAN TO
EX SINGLE STORY STORAGE
EX STEEL SHED
BARN A.
BARN B.
FARM YARD.
EX. FARMHOUSE.
ARGAE LANE
ELEC. LINES
EX LEAN TO.
SITE LAYOUT PLAN 1:200.
EX. ENTRANCE TO SITE.
NORTH
0 2 4 6 8 10 20m.
GREENYARD FARM ST ANDREWS MAJOR
DESIGNCELL ARCHITECTURE LTD.


PR/SP/23
EX STEEL SHED TO BE REMOVED ALONG WITH HARDSTANDING
PROPOSED GARAGES FORMED IN PLAN OF EXISTING BUILDING
PROPOSED BOUNDARY
END OF EXISTING BUILDING TO BE REMOVED
PROPOSED BOUNDARY
EXISTING ROOF AND MAIN STRUCTURE TO BE REMOVED LEAVING ORIGINAL DWARF WALLS AS SHOWN
PROPOSED GARAGE
PROPOSED GARAGE.
EX STEEL SHED TO BE REMOVED AND GARDEN FORMED
PROPOSED GARDEN.
BARN A.
PROPOSED GARDEN
ENT.
PROPOSED GARDEN
PATIO AREA.
TURNING BAY.
TURNING BAY.
ENTRANCE.
EX ACCESS TO SITE OPPOSITE
PROPOSED BOUNDARY
BARN B.
PROPOSED GARDEN
EXISTING FARM HOUSE.
EX OUTBUILDING
ENTRANCE
EX. GARDEN.
SITE LAYOUT PLAN 1:200
NEW TARMAC ROAD FORMED
TURN. BAY.
EX. STONE WALL TO BE MADE GOOD AND LINKED TO NEW GARAGE
EX. GARDEN
NORTH
EXISTING ENTRANCE TO SITE TO BE KEPT FORMING ACCESS TO RESIDENTIAL BUILDINGS ONLY
PROPOSED GARAGE.
PROPOSED GARAGE
0 2 4 6 8 10 20m
GREENYARD FARM ST ANDREWS MAJOR
DESIGNCELL ARCHITECTURE LTD.
PROPOSED BOUNDARY

Appendix EDP 2

Historic England (2016) *'Energy Efficiency and Historic Buildings: Insulating Timber-Framed Walls'*

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Historic England

Energy Efficiency and Historic Buildings

Insulating Timber-Framed Walls

Summary

This guidance note provides advice on the methods, materials and risks involved with insulating the walls of timber-framed buildings. Making improvements can improve comfort for occupants as well as lowering fuel bills and carbon emissions. However, such improvements can raise significant technical and conservation issues.

Timber-framed buildings are a striking feature in many of England's towns, villages and farmsteads. Examples can date back to the 12th century but most have 16th century origins. They continued to be built up to the 19th century in rural parts of the country. Many timber-framed buildings retain significant fabric and finishes, such as wall paintings and historic wattle and daub. Any repair or improvement should be devised to minimise the risk of harm to the historic fabric.

Often the timber-frame might be concealed by historic claddings, such as render, slate or tile-hanging and weatherboarding. Alternatively, the timber-frame can be fully exposed with infill panels of render, wattle and daub or brickwork. Some timber-frames are completely concealed behind masonry. Internally the timber-frame can be concealed behind lath and plaster or exposed with plastered infill panels. The variations found within this building type add considerably to their charm and character.

There are instances where wall insulation may be acceptable. However, this should only occur after a thoroughly detailed assessment has been made of the particular building, taking into account the often complex performance characteristics. Any solutions may need to adapt to take account of the significance, orientation, exposure and condition of an individual wall.

This guidance note has been prepared and edited by David Pickles. It forms one of a series of thirteen guidance notes covering the thermal upgrading of building elements such as roofs walls and floors.

First published by English Heritage March 2012
This edition (v1.3) published by Historic England January 2016.

Illustrations drawn by Simon Revill.

Our full range of guidance on energy efficiency can be found at
HistoricEngland.org.uk/energyefficiency

Front cover:
A vapour permeable membrane and tongue and grooved wood-fibre board has been added onto the frame below weatherboarding.
© Oxley Conservation.

Contents

1 Introduction

1.1 Energy Planning

Before contemplating measures to enhance the thermal performance of a historic building it is important to assess the building and the way it is used in order to understand:

- the heritage values (significance) of the building
- the construction and condition of the building fabric and building services
- the existing hygrothermal behaviour of the building
- the likely effectiveness and value for money of measures to improve energy performance
- the impact of the measures on significance
- the technical risks associated with the measures

This will help to identify the measures best suited to an individual building or household, taking behaviour into consideration as well as the building envelope and services.

1.2 Technical Risks

Altering the thermal performance of older buildings is not without risks. The most significant risk is that of creating condensation which can be on the surface of a building component or between layers of the building fabric, which is referred to as 'interstitial condensation'. Condensation can give rise to mould forming and potential health problems for occupants. It can also damage the building fabric through decay. Avoiding the risk of condensation can be complex as a wide range of variables come into play.

Where advice is given in this series of guidance notes on adding insulation into existing permeable construction, we generally consider that insulation which has hygroscopic properties is used as this offers a beneficial 'buffering' effect during fluctuations in temperature and vapour pressure, thus reducing the risk of surface and interstitial condensation occurring. However, high levels of humidity can still pose problems even when the insulation is hygroscopic. Insulation materials with low permeability are not entirely incompatible with older construction but careful thought needs to be given to reducing levels of water vapour moving through such construction either by means of effectively ventilated cavities or through vapour control layers.

The movement of water vapour through parts of the construction is a key issue when considering thermal upgrading, but many other factors need to be considered to arrive at an optimum solution such as heating regimes and the orientation and exposure of the particular building.

More research is needed to help us fully understand the passage of moisture through buildings and how certain forms of construction and materials can mitigate these risks. For older buildings there is no 'one size fits all' solution, each building needs to be considered and an optimum solution devised.

1.3 Technical Details

The technical drawings included in this guidance document are diagrammatic only and are used to illustrate general principles. They are not intended to be used as drawings for purposes of construction.

Older buildings need to be evaluated individually to assess the most suitable form of construction based on a wide variety of possible variables.

Historic England does not accept liability for loss or damage arising from the use of this information.

2 Timber-framed Wall Construction

2.1 The structural frame

The timber-frame is usually the primary structural component of the building which is made weather-tight with timber or tile cladding or with infill panels of wattle and daub, plaster or brick. The structural performance of a timber-framed building is dependent on the strength and condition of the joints that make up the frame. The failure of a single timber or joint as a result of decay and/or alteration can impose unpredictable additional stresses and loads upon other timbers within the framework. This can lead to the distortion of the frame and to the failure of parts of the building.

In many buildings the process of repair and adaptation will result in a 'composite construction' with both masonry and timber framing providing varying degrees of structural support. The particular circumstances, construction and performance of each timber-framed building, and in many cases each part of the building, will need to be individually assessed before making any changes. If the structural importance of the frame is not properly understood, the stability of the building can be threatened by well-intentioned but inadvertently damaging repairs or improvements.

2.2 Types of construction

Timber-framed buildings are constructed from a series of prefabricated timber-frames (cross frames, wall frames, floor and roof frames) joined one to another dividing the building into bays.

The two main types of timber-framed building are cruck and box frames and variations on both themes can be highly characteristic of both date and locality. The longevity of timber-framed buildings means that the timber-frames will very often have been adapted over the centuries, creating hybrid forms.

The timbers most commonly used to construct medieval timber-frames were oak and elm but from the 18th century onwards imported softwood was used. The same fundamental principles apply to the timber-frame irrespective of the species of timber used that is the timbers need to be kept free of prolonged damp.

There are many different types of cladding and infill panels used with timber-framed buildings. The traditional presentation of the building is important as it can reflect regional styles and the materials locally available as well as the social status of the building. These local traditions and styles should be recognised in any repairs or improvements.

In many timber-framed buildings the cladding and infill panels have been replaced over time. It is not unusual to find several types of infill panel in the same building, from original wattle and daub or early brick infill through to modern materials. These illustrate the history of the building and changes in available materials and skills over the lifetime of the building. Unless the infill panels are causing a problem they should normally be retained as a record of the building's history.




Figures 1-4
There are many variations in the construction of timber framed buildings resulting in a wide variety of thermal performance.

2.3 Breathing performance

Traditional timber-framed walls have very different characteristics to modern walls. They are typically built of materials that are capable of absorbing and releasing moisture freely, both internally and externally. They do not incorporate damp proof courses or air and vapour control layers which are a feature of modern timber frame construction.

2.4 Thermal performance of timber framed walls

The walls of a timber-frame building are usually relatively thin compared with masonry and earth-walled structures. Their thermal performance varies considerably depending on construction and on the materials used for infill panels and linings. Some timber-framed walls have little thermal mass, and can therefore be prone to large fluctuations in internal temperature for a cycle of solar thermal gain during the day followed by rapid cooling at night.

The importance of 'breathing' performance

Most traditional buildings are made of permeable materials and do not incorporate the barriers to external moisture such as cavities, rain-screens, damp-proof courses, vapour barriers and membranes which are standard in modern construction. As a result, the permeable fabric in historic structures tends to absorb more moisture, which is then released by internal and external evaporation. When traditional buildings are working as they were designed to, the evaporation will keep dampness in the building fabric below the levels at which decay can start to develop. This is often referred to as a 'breathing' building.

If properly maintained a 'breathing' building has definite advantages over a modern impermeable building. Permeable materials such as lime and/or earth based mortars, renders, plasters and limewash act as a buffer for environmental moisture, absorbing it from the air when humidity is high, and releasing it when the air is dry. Modern construction relies on mechanical extraction to remove water vapour formed by the activities of occupants.

As traditional buildings need to 'breathe' the use of vapour barriers and many materials commonly found in modern buildings must be avoided when making improvements to energy efficiency, as these materials can trap and hold moisture and create problems for the building. The use of modern materials needs to be based upon an informed analysis where the implications of their inclusion and the risk of problems are fully understood.

Where insulation is introduced it is important that this breathing performance is taken into consideration, or it may create problems for the building and its occupants.

Materials used in the repair, maintenance and improvement of traditional buildings must be selected with care. Modern impermeable materials – not just vapour control layers but cement based renders, plasters and pointing and most modern plastic-based paints will impair the breathable performance and will tend to increase the risk of condensation and trap moisture within the fabric.

Where moisture is trapped against the timber frame, as a result of using impermeable materials in past programmes of repair and decoration and/or other causes such as defective roofs and rainwater gutters, it can lead to serious problems of decay to the structural timber frame. Before making any improvements it is therefore important to examine the condition of the timber frame in detail.

The thermal performance of timber-frame walls is often made considerably worse by the presence of cracks and gaps between the timber-frame and infill panels and within the fabric of the infill panels and/or cladding itself. These cracks can often pass right through the walls, allowing large amounts of uncontrolled air infiltration (draughts) and consequent additional heat loss. They are a result of shrinkage of the materials used in construction, subsequent repairs and from structural or differential thermal movements.

2.5 Plinth and solid walls

Timber-framed buildings were normally constructed with the lowest horizontal timber (the sill beam or sill plate) resting on a masonry plinth wall. One of the functions of this wall was to isolate the timber frame from the damp ground. This was possible without using a damp–proof course by allowing the maximum of evaporation from the surface of the permeable plinth material.

Where timber-framed buildings incorporate masonry either as plinth walls or where the timber-frame has been under-built or covered by a masonry façade particular care should be taken to ensure that the masonry does not retain moisture which could harm the timber-frame. However, as with all ‘breathable’ buildings, periods of occasional dampness are not usually a problem if the construction is able to dry out rapidly afterwards.

Figure 5
The most vulnerable part of the timer frame to damp is the lowest horizontal timber the sill beam or sole plate as this is the timber nearest the damp ground.

2.6 Damp

Persistent dampness diminishes the thermal performance of a wall, and causes deterioration of vulnerable building fabric. If the timber-framed building is well maintained and there is a good projection of the roof eaves and verges then a timber-framed wall should not suffer from prolonged damp. The relative thinness of the walls, and the high surface area to volume ratio, will allow moisture to evaporate readily where the wall is constructed and finished with permeable materials.

For a timber-framed building in good condition the principal source of damp problems will be driven rain causing damp to penetrate through thin walls or through gaps between the timber-frame and infill panels. Even for thin walls the permeable qualities of traditional materials will, in all but the most extreme of conditions, help reduce the risk of serious problems of water penetration to the internal face of the wall. Plinth walls may also be affected by penetrating or rising dampness.

Where a wall regularly suffers from penetrating damp because it is exposed to prevailing winds, there may be a case for providing it with a protective coating or cladding, such as lime washes, lime slurries or lime render, or in particularly severe locations, tile or slate hanging or weatherboarding. Local precedents should be followed if possible. Such an alteration is likely to require consent for listed buildings and may require planning permission for other buildings.

The most damaging decay to a timber-framed building is usually found where inappropriate materials have been used to repair the building. The introduction of impermeable materials, such as cement-based renders and modern paints, will significantly increase the risk of water being trapped within the fabric resulting in prolonged dampness causing decay. Decay in the timbers of a historic timber-framed building is not only an aesthetic problem, it can also result in the loss of structural integrity

Figure 6
A hard cement mortar has been used to fill the gap at the edge of a brick panel. As the mortar is inflexible it has cracked and will trap moisture against the frame possibly leading to decay.

3 Issues to Consider Before Insulating

Adding insulation to timber-framed buildings demands great care to ensure the risk of surface and interstitial condensation are not increased, and that problems of damp and associated decay are not exacerbated.

It is important to remember that infill panels within the timber-frame can have as much historical significance as the frame itself, and improvements should not endanger those panels by trapping moisture against the timbers or the panels.

3.1 The timber-framed walls

It is important to understand the construction and condition of the timber frame and the solid wall elements so that the appropriate approach can be applied to these different forms of construction. The condition of the timber-frame is often dictated by the condition of the external cladding and infill panels and whether they have been repaired or replaced with inappropriate impermeable materials. The significant historic

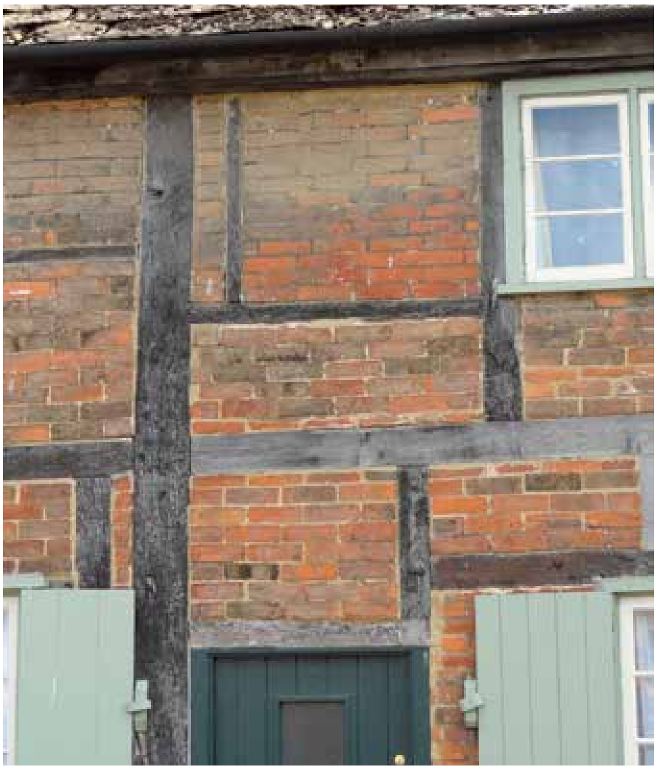

Figure 7 (left)
A timber framed cottage with brick infill panels.

Figure 8 (right)
A timber frame above a stone ground floor.

fabric (the timber-frame, infill panels and cladding) also needs to be identified so that repairs and improvements can be devised that take into account their special interest.

As in most cases the timber-frame is the primary structural component of the building, it is important that when any structural alterations are made appropriate professional advice is sought.

Great care is needed when making improvements to historic timber-framed buildings to ensure that highly sensitive and very rare fabric and finishes are not damaged or lost. The historic fabric found can include wattle and daub infill panels, which may be as old as the frame itself, historic render finishes that illustrate how the building was presented, brick infill panels and internal plasters and finishes such as traditional lath and plaster. Many historic timber-framed buildings may have remnants of wall paintings and decorations behind existing finishes.

With the repair and reinstatement of cladding and infill panels, it is important that traditional materials such as lime putty and earth based mortars and renders are used that are compatible and consistent with the traditional breathing performance. Timber-framed buildings are highly vulnerable to decay when the wrong materials are used. For this reason cement and high strength hydraulic lime based mortars and renders (NHL 3.5 and above) should not be used on historic timber-framed buildings.

3.2 The thermal performance

Time spent identifying areas that need attention, which elements of the building are not performing well, and where performance could be improved is well worthwhile. This can be achieved by using data loggers to accurately measure temperature and humidity levels. Pressure testing a building with a fan pressurisation test will help to determine how much air is leaking and infiltrating into the building and will quantify excessive heat losses. An appropriate plan can then be developed to reduce the scale of the problem and target resources where they are actually needed. For many timber-framed buildings the walls will be a primary source of excessive air infiltration.

Once suitable repairs have brought the building back to its original performance it is then possible to consider whether additional upgrading may be necessary or desirable.

Figure 9
Pressure testing a timber framed building can give a good indication of where there is excessive air infiltration. Such areas can then be targeted in any planned thermal upgrading.

3.3 Further investigation

Where the condition of the timber-frame is in doubt or where the presence of impermeable materials is a threat to the timber-frame it may be necessary to carry out some further investigation to ascertain the precise constructional detailing and the condition of concealed elements. Physical opening-up work should be kept to a minimum, especially where cement renders may have taken on a structural role, to reduce the risk of damage or disturbing the structural equilibrium of the building.

It some cases, it may be appropriate to use non-destructive survey techniques to gain a better understanding of the timber-frame condition. The following techniques can be useful, although all will need to be interpreted by an experienced professional:

- Calibrated resistance micro-drills can assist in determining the condition of the inside of timbers with the minimum level of disruption and can also clarify the internal arrangement of complex or unusual joints

- Thermal imaging can help identify timbers concealed by external render and internal plaster

An endoscope can enable visual inspection within small voids or behind rigid coverings although it may be necessary to drill a small hole to enable access.

3.4 Opportunities for upgrading

The difficulty and cost of upgrading thermal performance will mean that in many cases such works are only really viable if they can be incorporated into planned repair or improvement works. However, if it is necessary to repair the timber frame and cladding, this can provide a suitable opportunity to improve the thermal performance of the building. This will particularly be the case if it involves the removal of impermeable materials, such as cement renders.

The need for improved protection against driving rain would also provide the opportunity to improve the thermal performance of the building.

3.5 Materials

Natural insulation materials

It is important that the materials and methods used to improve the performance of a timber-framed building are compatible with its performance as a ‘breathing’ building. For this reason the selection of materials and the detailing of proposed solutions need great care.

There are many insulation materials available that have similar performance characteristics to traditional materials and these can be used to improve the thermal performance of these buildings without compromising their permeability. These materials include:

- wood-fibre-board,

- sheep’s wool batts,

- hemp-fibre insulation boards

- flax-fibre batts

- cellulose fibre

In many cases these will be used with vapour-permeable ‘breather’ membranes.

Insulation systems based on cement-based or acrylic renders, or including impervious membranes should not be used on a historic timber-framed building. There are many cases of cement-render having caused serious problems of decay to the structural frame. The use of impermeable plastic-based paints should also be avoided both internally and externally.

Well-intentioned improvements can lead to the introduction of new technical risks, either because of poor detailing at the design stage or inadequate care during installation. Very minor errors can lead to serious problems. For example, where vapour control layers are used, even small perforations can lead to severe problems of damp, especially in rooms where large amounts of water vapour are produced.

Hemp-lime composites

Hemp-lime composite materials have been successful in France and more recently in the UK and Ireland in providing compatible insulation which can infill timber-frames. The material has also been successful in meeting very demanding thermal performance targets in new buildings. The material is based on chopped hemp 'shiv' (the remains of the woody stem of the plant) mixed with specially developed lime based binders. It can be mixed conveniently on site to give a lightweight 'concrete' or 'hempcrete' containing a great deal of air. It is then finished externally and internally with lime renders, cladding or clay plasters.

The resulting material is a rigid cast insulation which can accommodate a certain amount of movement in the timber frame and which is highly compatible with the moisture behaviour of the timber itself. It also has inherent thermal mass and can therefore help to dampen out the internal temperature fluctuations which can be such a problem in lightweight construction (typically 10mm or so), or it can be cast to a greater thickness if the opportunity arises.

Figure 10
Hemp-lime being installed as an infill panel.

Figure 11
Hemp-lime is a mix of chopped hemp mixed with a lime based binder.

4 Improving Thermal Performance

4.1 Exposed timber frame walls

Where the timber frame and the infill panels are both exposed it is more difficult to improve the performance than if the frame has an overall cladding. In many cases, the addition of external insulation under a weather-screen cladding offers the best configuration for wall insulation. Such an arrangement allows the insulation to bridge cracks and to protect the frame and the original panel material. If no external cladding is already present this may well unacceptably compromise the character of the building.

Additional insulation may well make the wall thicker, requiring modifications to eaves and window reveals which can add significantly to both the cost and the disruption.

4.2 Gap filling

One of the characteristics of timber-framed buildings is that there can be a high number of cracks and gaps in the construction, particularly between the timber frame and infill panels. Some of these sources of draughts will be obvious to a visual inspection (chinks of light) or to an occupant on a cold windy day feeling the draughts. However, a more thorough and far more effective way to identify all the cracks and gaps will be to carry out an air pressure test.

The most effective improvement that can be made is to fill the gaps, as air passing through these simply by–passes even the limited insulation capability of a narrow wall. How to fill gaps and cracks will depend upon their size, location, exposure and on the materials used for the infill panel itself. Traditional lime-putty mortars with hair are often a very suitable filler to minimise cracking and maintain compatibility with lime-based panel materials. Filling the worst cracks with such mortar is a simple cost effective method to create an improved internal environment for the occupants and to reduce heating bills. Silicone mastics, car body filler, cement, and many other impermeable sealants are totally incompatible with traditional construction and should be avoided.

4.3 Removed infill panels

Where infill panels have to be removed, possibly as they are of unsuitable materials or to facilitate structural repair to the frame, this would provide the opportunity to replace them with insulated panels.

4.4 Insulation between the frame

Rendered elevations

Where historic renders survive they should be retained and not removed to facilitate the insertion of insulation. However, where render is to be removed, for example where it has failed or is an inappropriate later cement render, there is an opportunity to insert insulation within the timber frame before the render is reinstated. Wherever the render is reinstated back to its original/existing profile this option need have no detrimental visual impact on the building.

A lime putty or earth based render will provide an effective barrier against excessive draughts keeping the insulation ‘warm’. As with any render, some shrinkage can be expected. This will allow some air infiltration but it should not be excessive. Regular maintenance with a traditional limewash finish will assist in filling any shrinkage or movement cracks which might develop.

Figure 12 (left)
Timber laths being added over a frame to take an external lime render. Sheep’s wool insulation has been added between the frame.
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Figure 13 (above)
Timber laths being fixed externally over a vapour permeable membrane.
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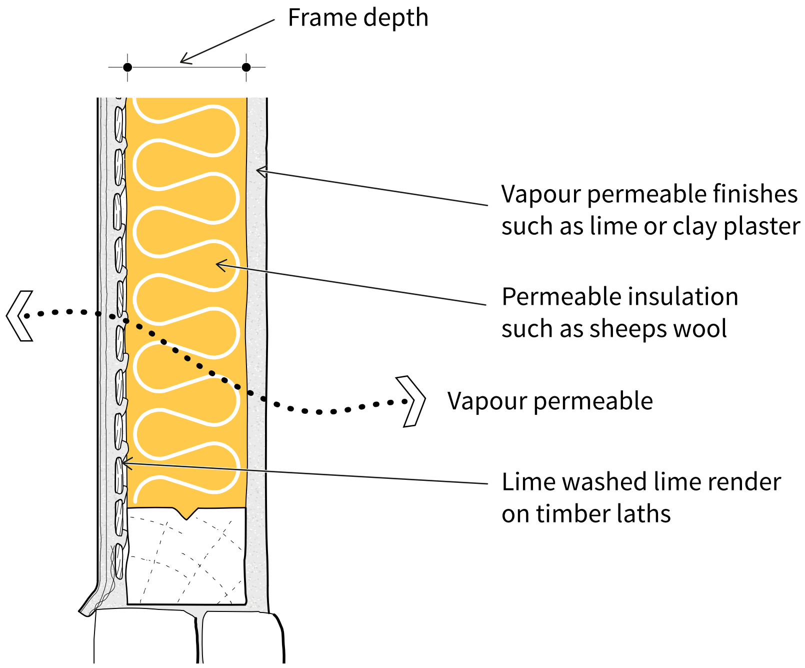

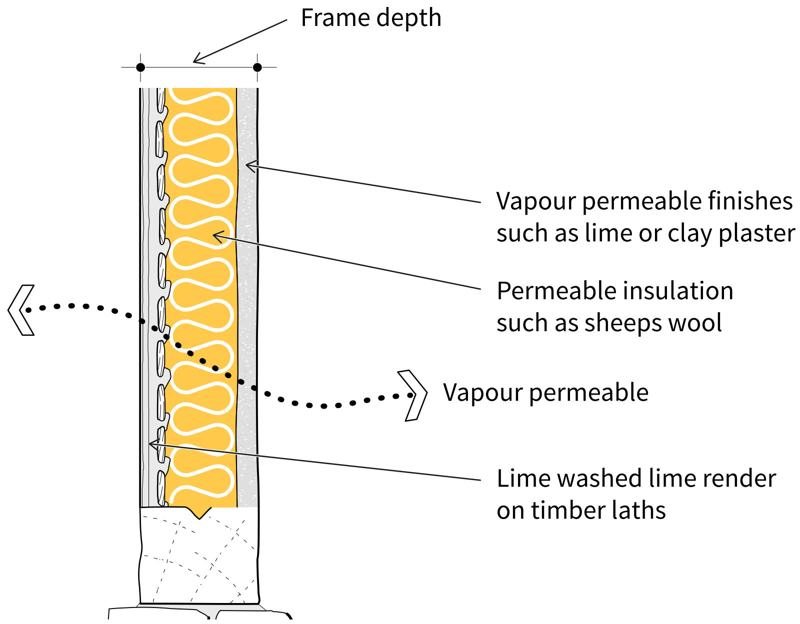

Figure 14 (above): Insulation within depth frame (Existing panels replaced and frame covered lime render).
Permeable insulation is shown here placed within the frame which is covered on the inside and outside with a lime render. Insulation materials such as hemp-lime, wood-fibre or sheep's wool could be considered. Such work could be carried out from the inside if the external lime render is to be retained.

Figure 15 (below): Insulation within depth of frame (Existing panels removed and frame exposed).
Permeable insulation is shown here within the depth of the frame which is exposed both externally and internally. This form of construction creates the problem of maintaining an airtight junction between the infill panel and the timber frame. The thermal efficiency in this situation will never match a frame that is covered.

Clad elevations

The removal of tile-hanging or weatherboarding for repair will also provide an opportunity to install insulation within the thickness of the timber-frame. Cladding can be relatively easily removed, and in the case of tile or slate hanging, can normally be re-used. The removal of weatherboarding is more difficult without causing some damage, particularly if any rot has occurred. Reinstatement of the cladding over a vapour permeable 'breather membrane', added as a secondary barrier behind the cladding, can significantly improve the performance and effectiveness of the insulation by reducing air infiltration. The breather membrane should be installed with some 'slack' behind the cladding particularly when used with weatherboarding so that it is not held tight to its back face. This will allow any water that penetrates the cladding to run freely away down the face of the membrane without being redirected against the timber cladding.

Figure 16
A vapour permeable membrane and tongue and grooved wood-fibre board has been added onto the frame below weatherboarding.
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4.5 Insulation outside and between the frame

External insulation is the most effective means of insulating a timber-framed wall. It can be achieved by fitting wood-fibre or other similar boards over the external face of the timber frame, taking care to seal any gaps between boards caused by the unevenness of the frame beneath. The disadvantage of such boards is that their fitting will change the position of the cladding, making the wall thicker. This will require consequential changes in window reveals, eaves projections, rainwater goods locations and other façade details that are costly to make and could have a material impact on the appearance of the building. Wood-fibre boards are available that are impregnated with latex. Such boards can act as a secondary barrier to any rain driven through the cladding. Other boards may require the provision of a vapour permeable membrane to protect them from driven rain.

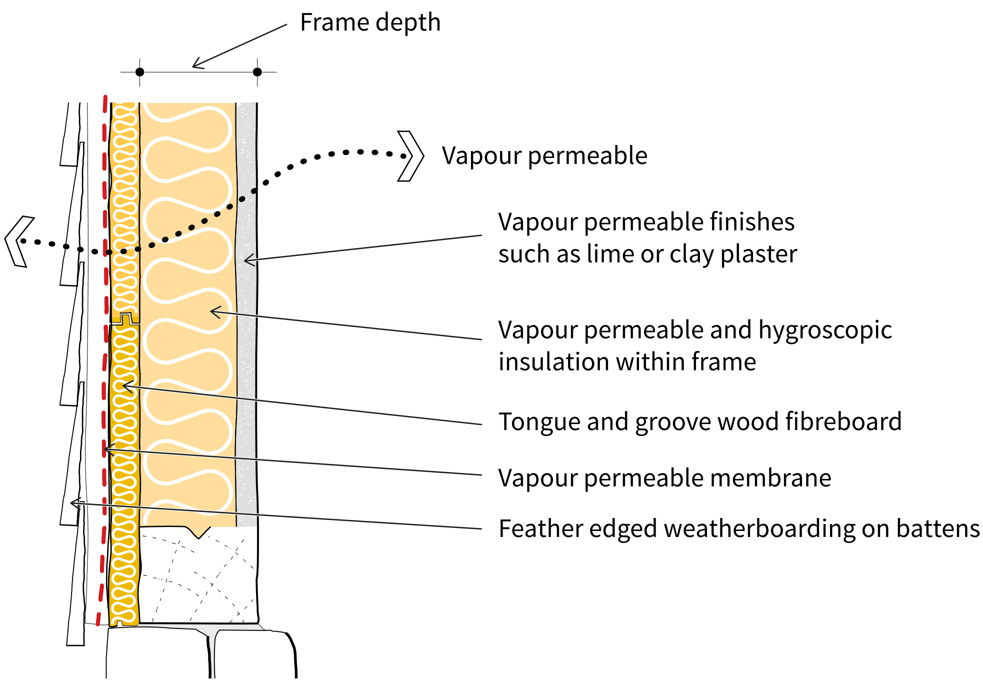

Figure 17: Insulation behind weatherboarding and between frame.
If weatherboarding or tile hanging needs repair or renewal then this can provide an opportunity for insulating both between the frame and to the face of the frame below the weatherboarding or tile hanging. Insulation on the outside of the timber frame may be the only possible way of upgrading the thermal performance of a wall if there are historic infill panels that cannot be removed.

4.6 Insulation inside the frame

The addition of internal insulation is possible for most timber framed walls, but such work can have major implications on the appearance of the walls, and will reduce the floor area of the rooms.

If the timber frame is visible on the inside it will be concealed by the insulation. If the main elements of the timber frame are substantial in depth and intermediate elements thinner, it may be possible that the insulation will only cover the intermediate elements, leaving the principal posts exposed. However, this is still a significant alteration and its effect on the character of the building should be carefully considered.

If the timber-frame is already covered by a plaster finish, there may also be valuable decorative cornicing and picture rails, skirting boards and in some cases door architraves that may be concealed or disturbed by the installation of insulation.

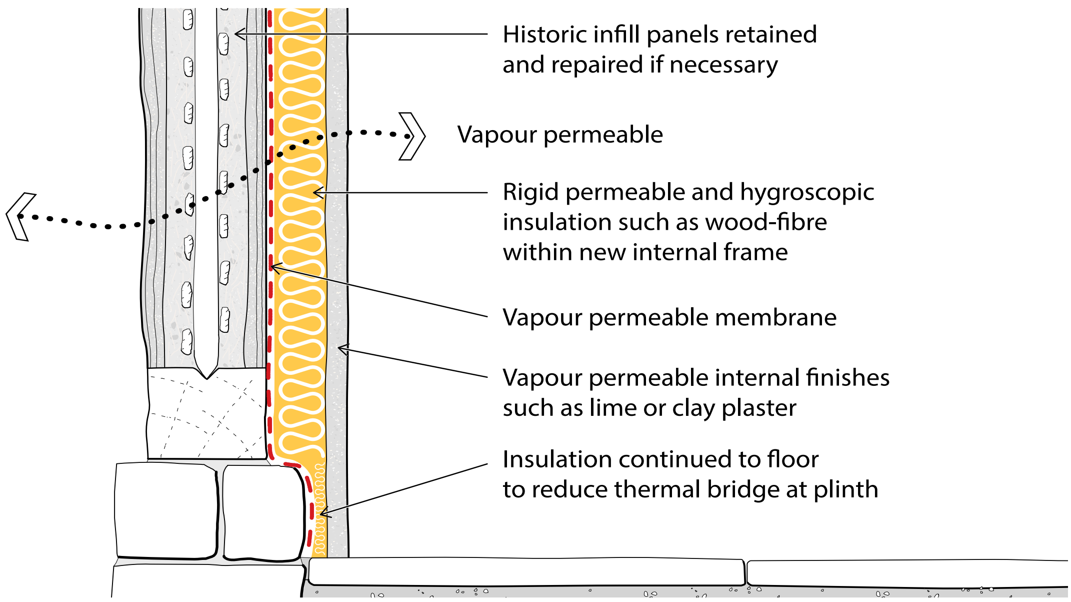

Figure 18: Insulation added to inside of frame (Existing panels retained).
Where infill panels within a frame have historic significance and need to be retained then insulation might be added to the inside. In order to maintain compatibility with the historic infill panels a vapour permeable insulation should be used together with a lime plaster finish internally so that any moisture that gets between the frame and the insulation can easily evaporate.

If internal insulation is separated from the timber-framed wall by a cavity, careful thought will need to be given to the movement of air and moisture within the cavity. Ideally, such a cavity should be ventilated to the outside, but this will require ventilators to the external wall which may well be unacceptable. If the cavity is not ventilated a void is created where damp air can collect which may cause rot in concealed areas.

Adding internal insulation can also create new problems, such as thermal bridges that did not exist previously. Areas with little or no insulation will not only be colder for the reasons outlined above, but will attract more moisture because other surfaces are warmer and can no longer share the load. In timber-framed buildings this risk is less than in solid masonry but care still needs to be taken, particularly where only partial improvements are being made.

Insulating the walls above and below a suspended timber floor can create a cold bridge where the floor meets the external wall. The ends of floor joists embedded in the external walls are at increased risk of decay from condensation and the damage is also usually concealed from view.

In listed buildings, consent will usually be required for any internal alterations that affect the appearance and character, including any materials, details and finishes of historic or architectural interest.

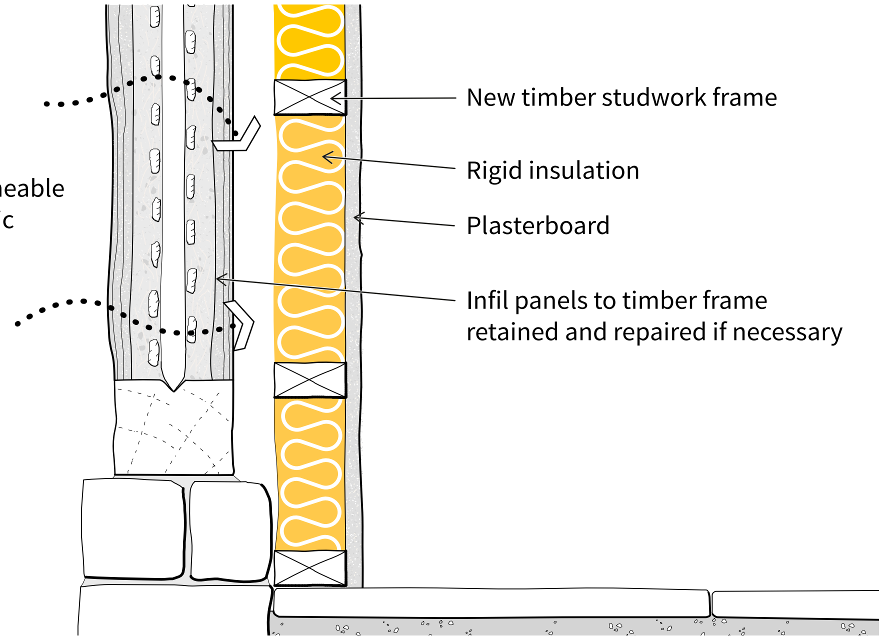

Figure 19: Insulation added to inside of frame with cavity (Existing panels retained).
An impermeable insulation is used here and detached from the frame with a ventilated cavity. The difficulty with this form of construction is ensuring the cavity is adequately ventilated to disperse any moisture that finds its way into the cavity.

5 Where to Get Advice

This guidance forms part of a series of thirteen documents which are listed below, providing advice on the principles, risks, materials and methods for improving the energy efficiency of various building elements such as roofs, walls and floors in older buildings.

This series forms part of a wider comprehensive suite of guidance providing good practice advice on adaptation to reduce energy use and the application and likely impact of carbon legislation on older buildings.

The complete series of guidance is available to download from the Historic England website: HistoricEngland.org.uk/energyefficiency

Roofs

- *Insulating pitched roofs at rafter level*
- *Insulating pitched roofs at ceiling level*
- *Insulating flat roofs*
- *Insulating thatched roofs*
- *Open fires, chimneys and flues*
- *Insulating dormer windows*

Walls

- *Insulating timber-framed walls*
- *Insulating solid walls*
- *Insulating early cavity walls*

Windows And Doors

- *Draught-proofing windows and doors*
- *Secondary glazing for windows*

Floors

- *Insulating suspended timber floors*
- *Insulating solid ground floors*

For information on consents and regulations for energy improvement work see HistoricEngland.org.uk/advice/your-home/saving-energy/consents-regulations

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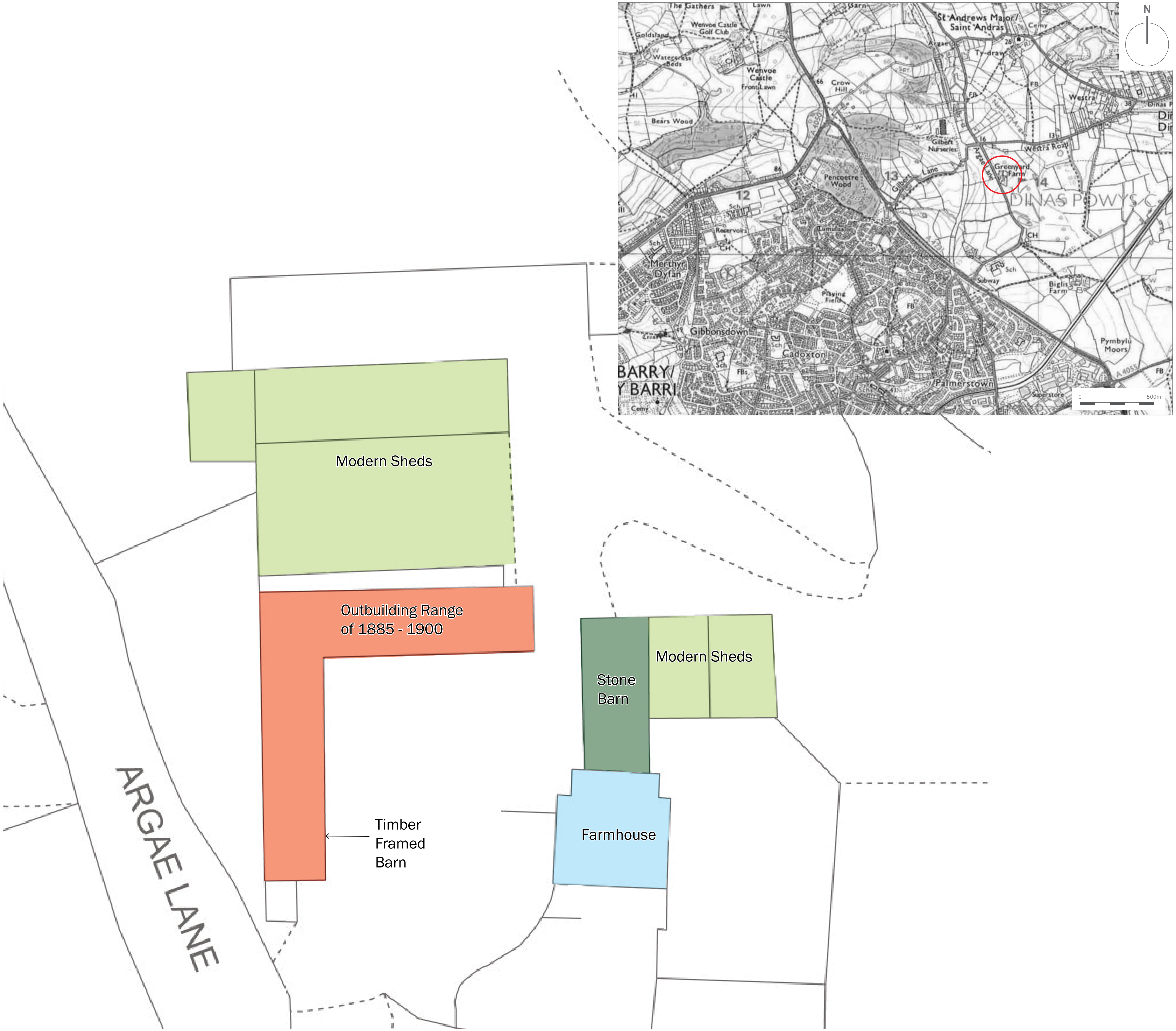

Site Location

client
St. Andrews Major Golf Club

project title
Greenyard Farm, St. Andrews Major

drawing title
Plan EDP 1: Site Location

date	27 JANUARY 2017	**drawn by**	GC
drawing number	EDP3411/01a	**checked**	AC
scale	Refer to scale bar	**QA**	LH

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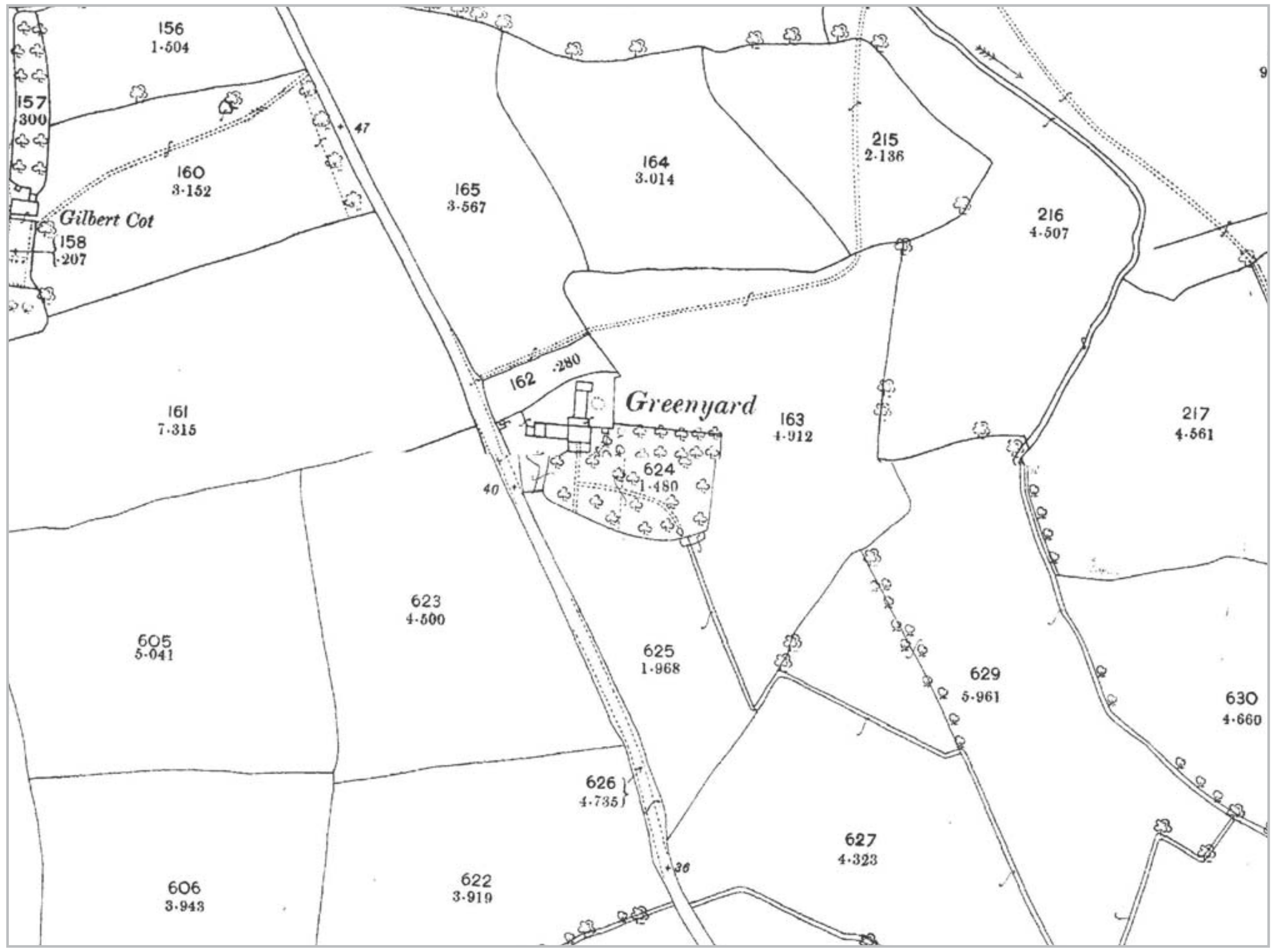
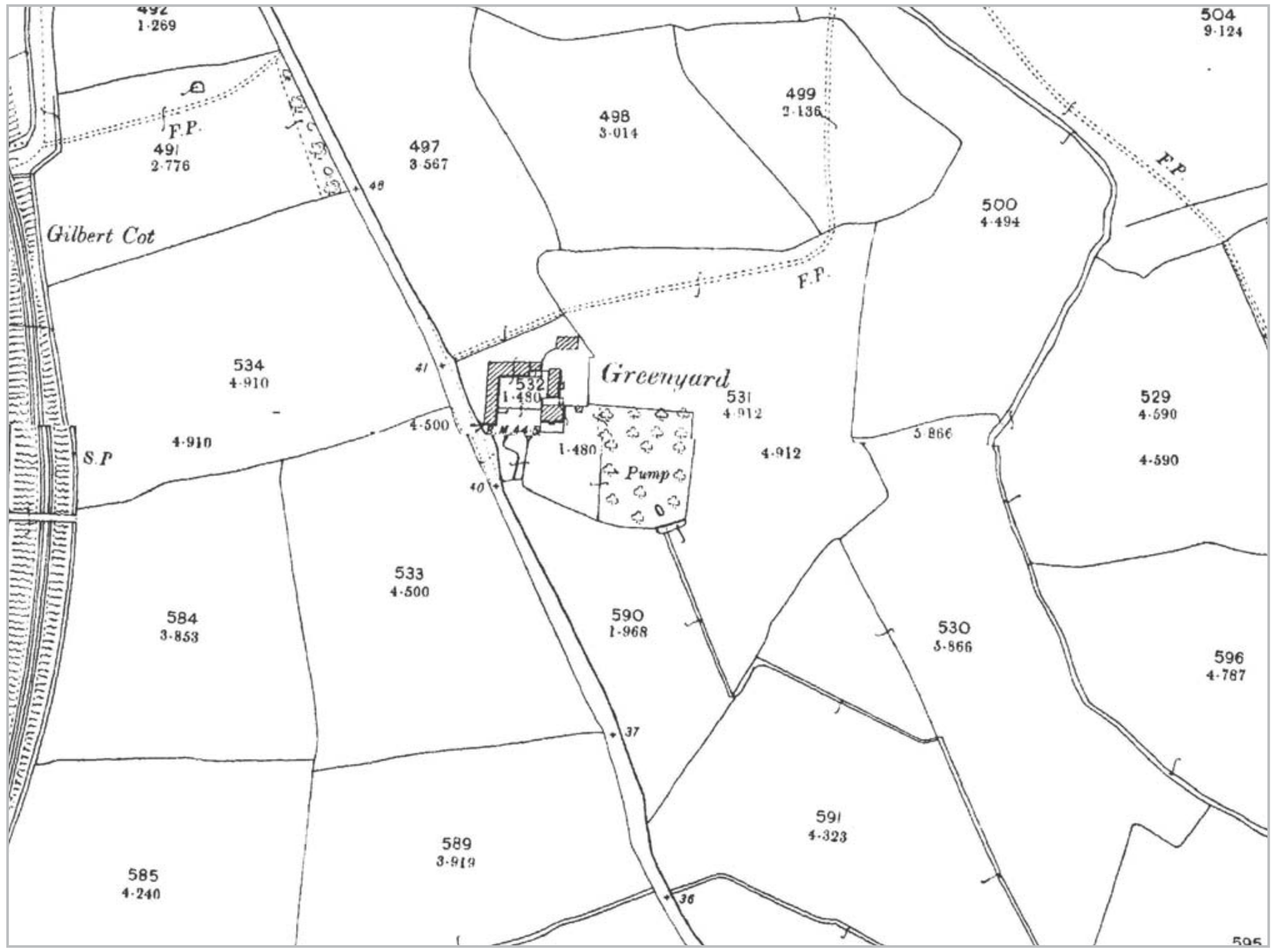


a) 1878



b) 1900

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client

St. Andrews Major Golf Club

project title

Greenyard Farm, St. Andrews Major

drawing title

Plan EDP 2: Extracts from (a) the first (1878) and (b) the second (1900) editions of the 25'' Ordnance Survey map

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