APPENDIX 4

Barn Designs for 40, 60, and 288 Goats *

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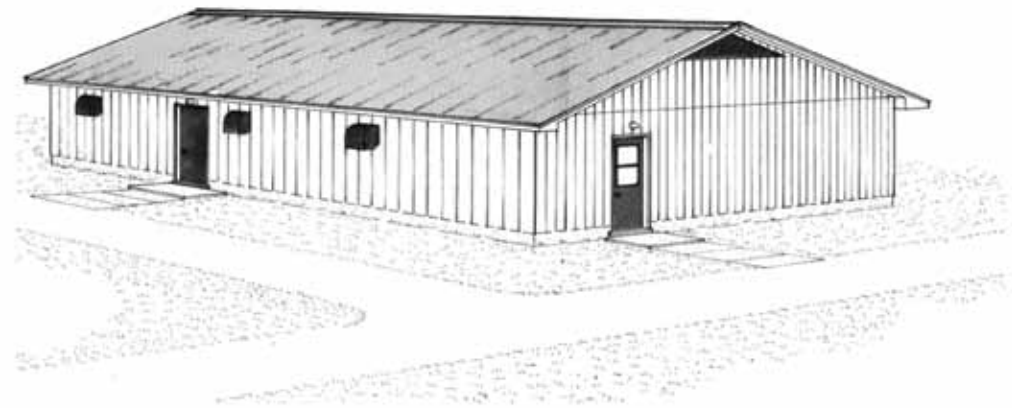
*The Agency of Environment and Sustainable Development and the Agency of Agriculture, Fisheries and Food of Quebec (MAPAQ), Chaudières-Appalaches, Estrie, and Central Quebec, have worked together to write this article. With permission, translation from the French by Jordan Le Roux and Carol Delaney with technical editing from Keith Kirchner. Original publication found at WWW.AGRIRESEAU.QC.CA

40-GOAT DAIRY BARN DESIGN**



This design illustrates a barn for 40 milking goats and their replacements. For a herd of this size, which represents a fairly considerable operation, certain functional installations are essential in order to ensure a good plan.

This goat barn measures about 36 by 70 feet; it is free standing and only has one level. At one end it houses a milk room of about 10 by 12 feet and a 10-goat milking parlor that measures about 11 by 24 feet.

A central area about 33 feet long houses the milking string. This area is divided in two parts by two sets of head gates; additional head gates are located at the requisite manger area at the end of the paddock. The other section of the barn comprises the kidding area and stalls for kids. There is also a grain room and a separate area for bucks.

This building of this barn requires construction of another building to store bedding and forage, with an access lane around the goat barn. However, this design imposes certain constraints on any future expansion to accommodate increasing herd size. In spite of that inconvenience, the design is well adapted and adequate for 40 milking goats.

**From MAPAQ publication 80265, "Chèvrerie de 40 Laitières." WWW.AGRIRESEAU.QC.CA. Translated by Carol Delaney.

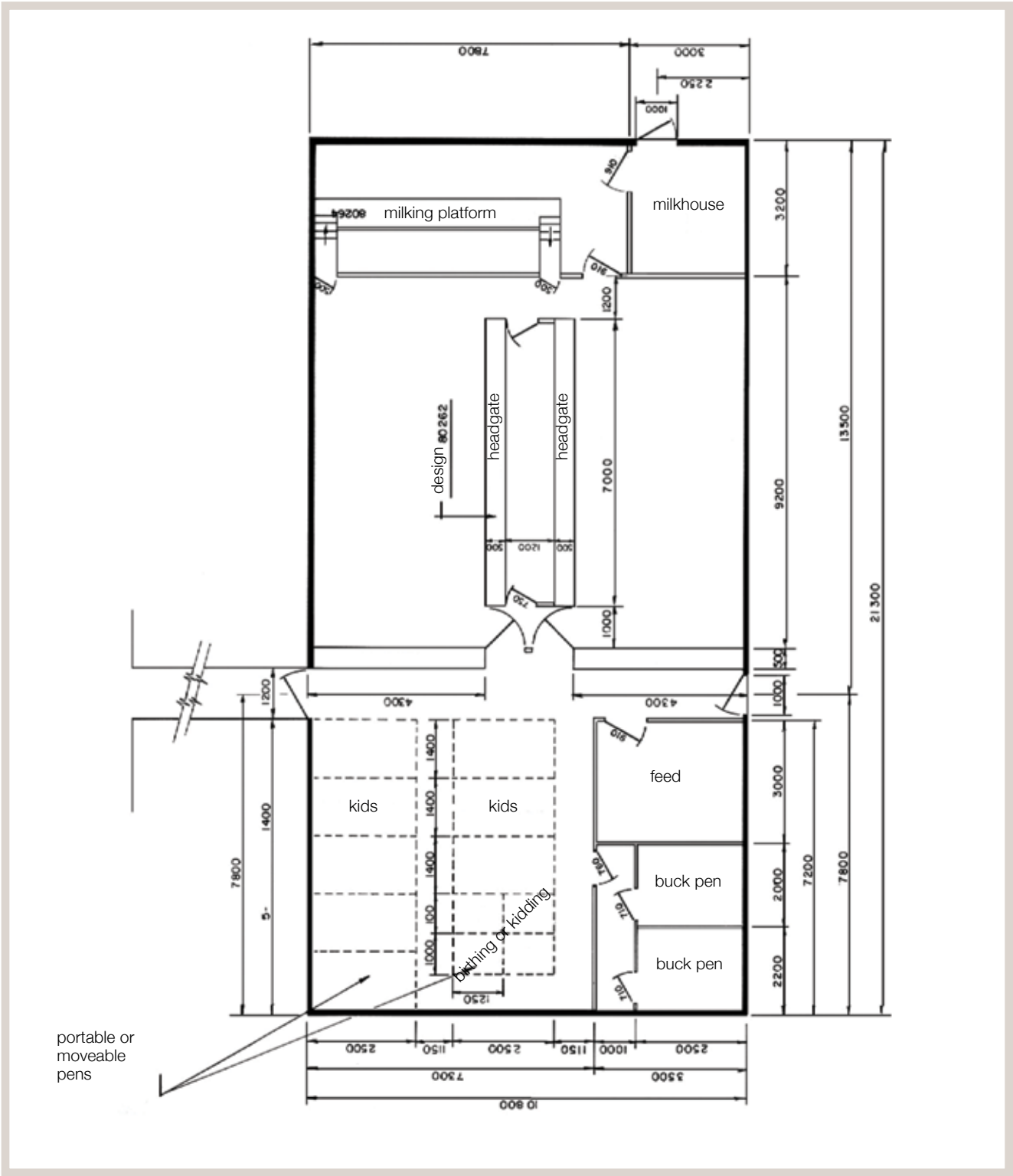
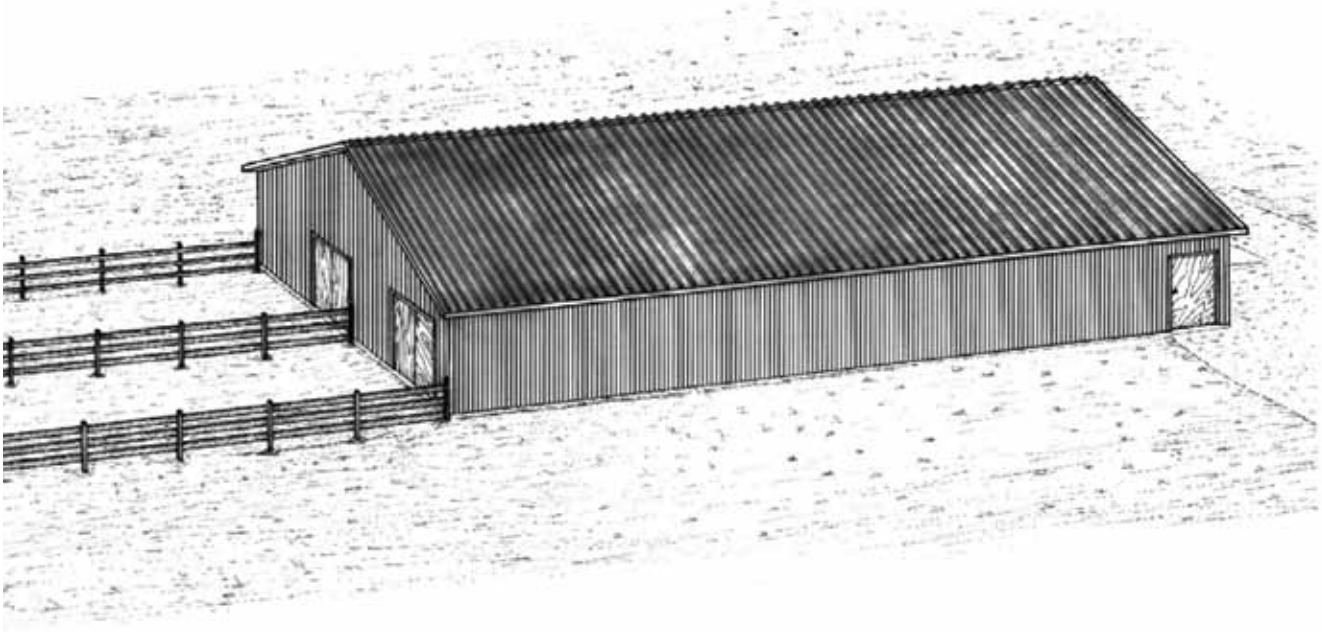


Figure A4.1 Floor plan for barn designed for a 40 goat dairy.

60-GOAT DAIRY BARN DESIGN*



This design illustrates a barn for 60 milking goats and their offspring. This size herd, being relatively substantial, necessitates a building well organized to permit an effectively ordered space.

This goat barn measures about 42 by 65 feet; it is free standing and has only one level. At one end it houses a milk room about 14 by 21 feet, a 10-goat milking parlor, a grain room, and a kidding area.

At the other end of the barn there are two pens for milkers, about 12 feet wide, each having a double door to the outside to permit the removal of bedding with a tractor. These pens are divided by a traffic alley bordered on each side by head gates. A series of stalls for raising kids is lined up along the opposite wall. Bucks are housed separately in a small building to prevent any odor contamination.

For storing hay and straw, one must plan to build another structure.

It must be noted that the parlor is only single sided because it is placed strategically near the milkers'pens and the holding area. This allows an efficient way of milking the groups in rotation. This type of plan permits for further expansion. The building can be added on to at the ends of the pen and stall section without a problem.

*From MAPAQ publication 80266, "Chèvrerie de 60 Laitières" at WWW.AGRIRESEAU.QC.CA. Translated by Carol Delaney.

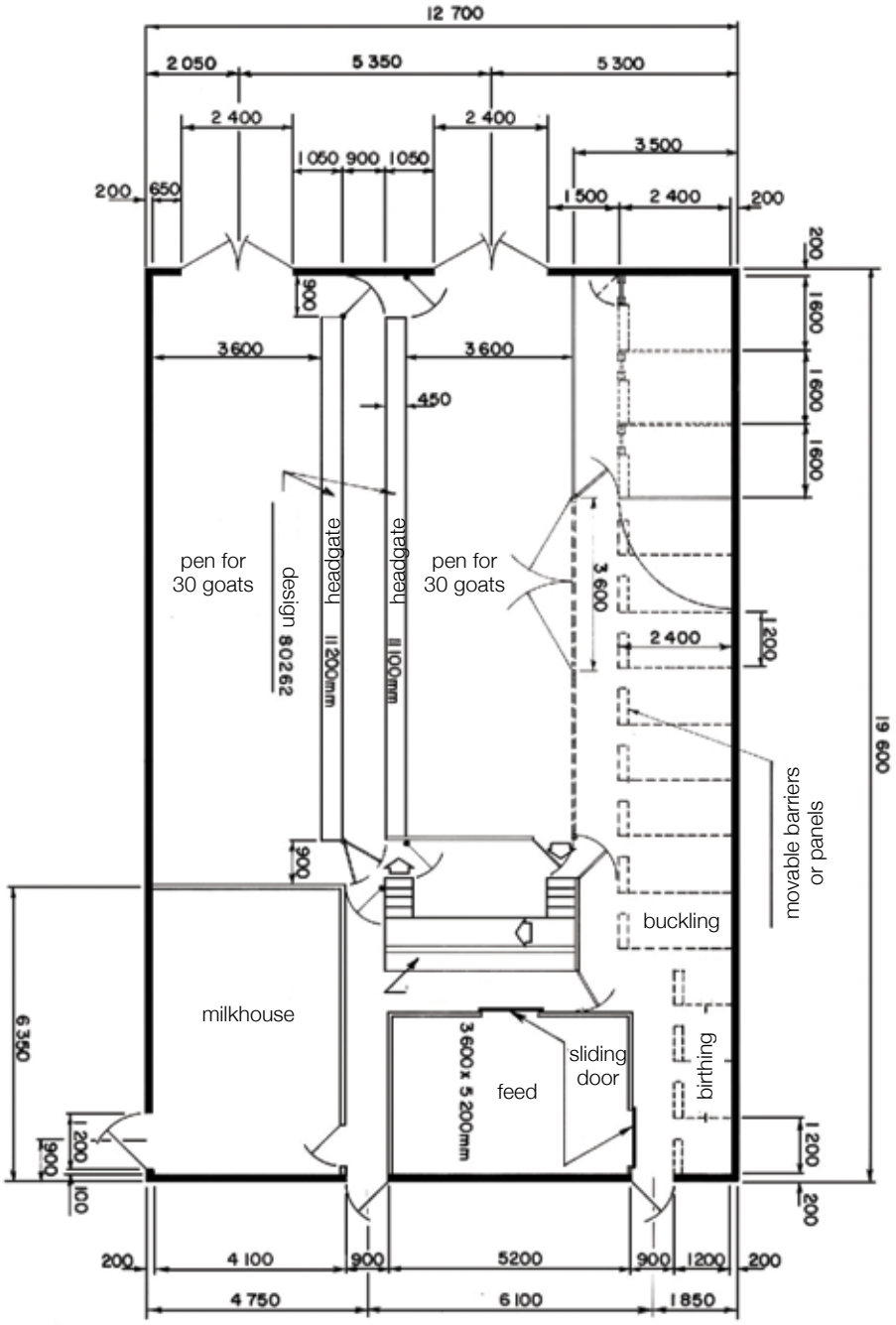
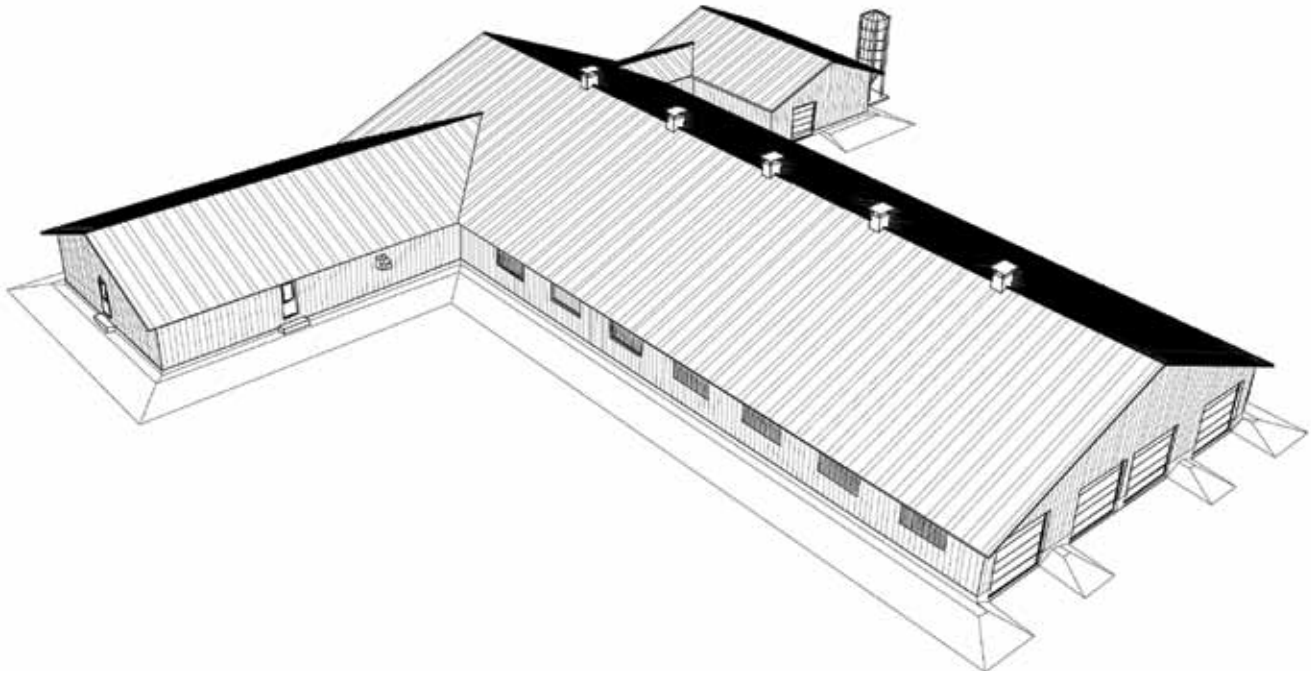


Figure A4.2 Floor plan for barn designed for 60-goat dairy (measurements in metric dimensions).

288-GOAT DAIRY BARN DESIGN WITH BEDDED PACK MANAGEMENT[1]



In any plan to build a goat barn, it is important to assess the number and the size of goat groups, especially for night and morning milking. Often, groups are established according to lactation stages and feed needs. They may also be established by criteria such as age, lactation rank, or due dates. Generally, the larger the groups, the more herd management is eased regarding time to work, to feed, and to milk. However, it is recommended that animals be grouped as homogeneously as possible.

The number of animals to house depends on herd management factors that include replacement or cull rate, the raising of yearling does or buck kids for meat management, and the farm objective (e.g., to sell breeding stock or meat goats).

The pit and holding area in the milking parlor should be designed according to the number of people milking and number of goats to milk per group.

This article supplies the basics to build a barn for a 288-dairy goat operation. For this plan, there are four adult goat groups, a 36-unit milking parlor, and a 72-goat space for the holding area (see Figure A4.9). Raising kids and doelings, either for breeding or meat sales, is not considered in this article.

Compared to the documents 80265 and 80266 (originals at www.agrireseau.qc.ca/; see "40-Goat Dairy Barn" and "60-Goat Dairy Barn" in this appendix) that are buildings adapted for small herds (40 and 60), the main building is much larger than the barns designed for 40 and 60 goats in order to reduce distances for the goats during milking and other operations. A cathedral ceiling provides more air volume and eases ventilation.

Barn Layout

The barn shown here at a 69 foot width allows four strings of pens that will give you a building length of 158 feet. This compares to a narrower building that can only allow two strings of pens, which would then require the building to be 295 feet in length for the same number of goats. Although the floor space is somewhat reduced in the wider building, the construction cost is decreased significantly. This design also reduces the distance the animals must travel to the milking parlor by 35% as compared to the longer barn. The wing that includes the milk house, milking parlor, nursery, and other

[1] Translated with permission from authors by Jordan Le Roux, Keith Kirchner, and Carol Delaney.

rooms is located at one end of the building. The opposing wing allows for buck housing, feed mixing, and storage. This layout permits a barn addition without any changes in the milking operation.

Herd

The 6,630 square feet of floor space in the main pens can house 438 animals. This breaks down to 288 milkers (approximately 16 square feet per animal), 25 dry goats, and 125 yearlings 2 to 12 months old (based on a 30% annual replacement rate). The 516-square-foot nursery area is large enough to house approximately 110 doelings from birth to 2 months. Up to eight bucks can be housed in the opposite wing.

Housing

The barn is insulated and ventilated. Inside temperatures should remain between 50° and 60.8°F in the winter, and humidity should not exceed 80%. Particular attention is paid to newborns, which should be housed at 77°F. Given the difficulty in maintaining this climate in the main barn, a separate kid room with its own ventilation and temperature control has been fitted specifically for the young stock.

Pens for goats and yearlings are 12 feet wide. Table 4A.1 indicates goat requirements for this type of farm.

In order to keep goats away from the feed alleys (to prevent feed contamination), 2-foot-wide alleyways for animal traffic are provided [editor's addition: along the walls of the building]. Feed alleys are raised approximately 16 inches above floor level. The 7-foot width of the feed alley allows enough space to install a feed rack with mechanical headlocks.

Different types of headlocks can be used. In the case of free-choice feeding, a simple gate can be used. If forage distribution is controlled, it is better to have headlocks that block goats either by group or individually (Figures A4.3, A4.4, and A4.5, page 147). These types of headlocks assure better control of feed intake. To avoid feed waste in the trough, a 6-inch wooden panel is fixed at the bottom of the headlock.

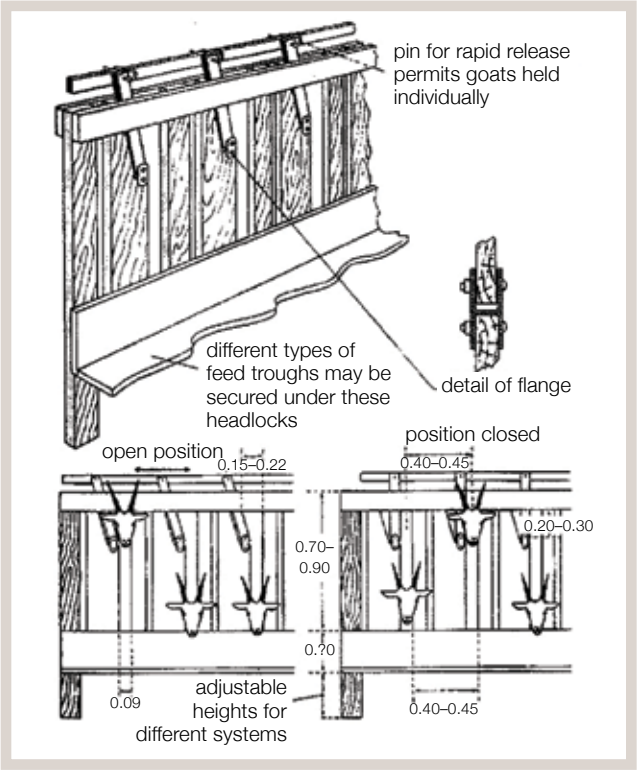


Figure A4.3 Headlock.

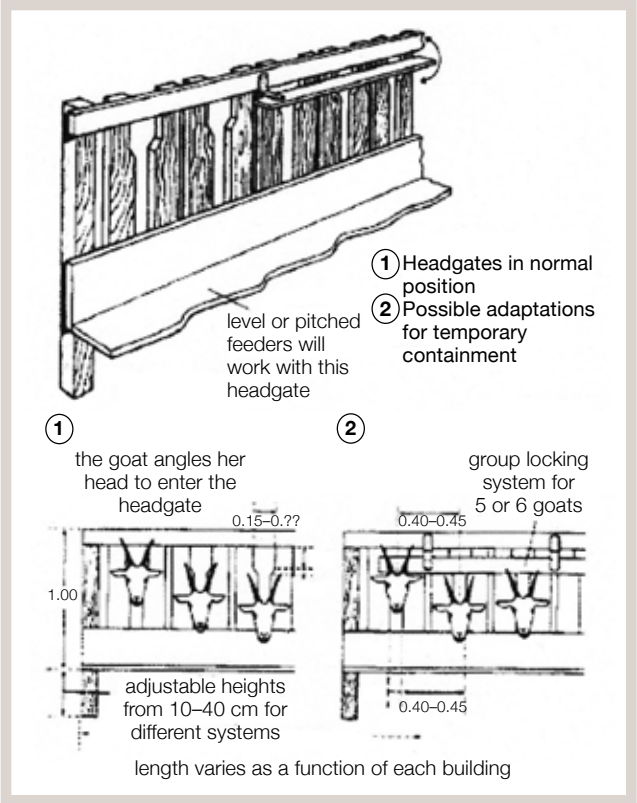


Figure A4.4 American headgates.

Table A4.1
Some Technical Design Measurements for a Dairy Goat Barn

		Weight of Goat	At Rest	In Activity
HEAT PRODUCTION	Sensible heat	79 lbs at 59°F	60 watts	86 watts
		130 lbs at 59°F	89 watts	126 watts
	Enthalpy change	79 lbs at 59°F	34 watts	42 watts
		130 lbs at 59°F	48 watts	62 watts
	Moisture production		± 1.76 oz of water/hour/goat	

VENTILATION	Continuous	79 lbs at 59°F	0.04 ft²/s	0.05 ft²/s
		130 lbs at 59°F	0.05 ft²/s	0.07 ft²/s
	Humidity control	79 lbs at 59°F	0.08 ft²/s	0.10 ft²/s
		130 lbs at 59°F	0.14 ft²/s	0.24 ft²/s
	Heat control	79 lbs at 79°F	0.60 ft²/s	0.90 ft²/s
		130 lbs at 79°F	0.90 ft²/s	1.27 ft²/s

PREFERRED AMBIANCE	Minimum temperature	50 to 60°F (77°F for newborn)
	Maximum temperature	<80°F
	Moisture	65 to 80%
	Maximal air speed	1.64 ft/s (0.5m/s) = adults 0.65 ft/s (0.2m/s) = birth to 2-month-old kid

		Floor Space (sq ft/head)	Linear Feed Space (inch/head)
BUILDING	Adult	16.00	15.75
	Doeling from 7 to 12 months	11.00	14.00
	Doeling from 2 to 7 months	8.60	13.00
	Kid	3.25	6.00
	Buck	32.30	17.75
	Holding area	2.7 to 3.2	

WATER	Water quantity	0.80 to 3.2 gals/head/day
	Water bowl	1 per 25 head
	Water bowl height	35 inches from floor
	Location	Opposite side of headlocks

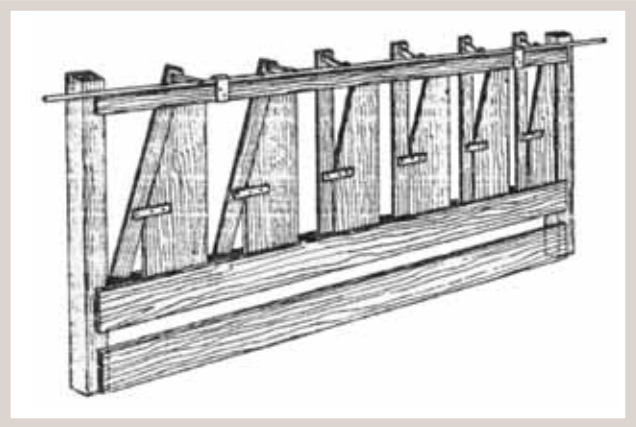


Figure A4.5 Self-locking headgates.

Gates 11.5 feet wide allow you to divide pens. Ideally, you could install a system that would allow you to progressively raise these gates as the bedding pack builds up.

Construction

Before building, contact the [state] department of agriculture to help you check the laws and regulations; i.e. milk house, milking parlor, construction, and manure management should be discussed with the Department of Agriculture.

Foundation and Floor

The barn has an 8-inch-deep by 16-inch-wide reinforced (rebar) concrete footing with 8-inch-wide reinforced concrete walls. The footing must be placed below the frost line and be adequately drained. The frost line varies according to weather conditions in each location and should not be less than 4 feet in northern climates but local codes should be consulted. The colder the climate — the deeper the footing.

Exterior walls should be insulated where possible in order to minimize thermal losses in the winter months. The thermal losses are limited by a type 4 polystyrene expanded and extruded insulation applied in all building perimeter. A floated paving stone may possibly be used in place of a deep foundation in some locations around the main barn area. In that case, the paving stone should rest on filling materials (sand/gravel) 12–24 inches deep according to soil type. To use the paving stone, filling materials should be compacted in successive layers of 4–6 inches deep at 95% modified proctor.

When the soil has more clay, the thickness of the embankment is important. A drain allows to removal of water infiltration near the building and to prevent heaving risks by freezing. Details should be provided by an agricultural engineer and consult your local codes for guidance.

The milk house, milking parlor, and kid area should be built on a conventional foundation as some of these areas have different [elevated] floor levels [that require strong support].

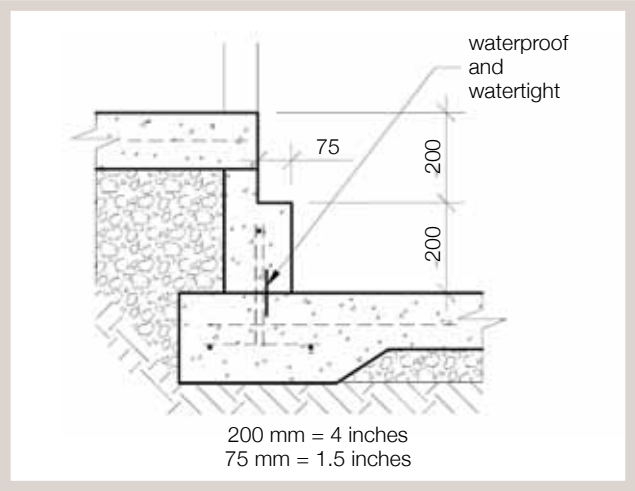


Figure A4.6 Foundation designed to be watertight (dimensions metric).

All alleyways, pens, and floors that animals will travel on should be constructed of 5-inch or more reinforced concrete, 3,500 psi, with a water/cement ratio of 0.45 and an air incorporation rate of 6%. Concrete should not be troweled too smooth, but instead should have a somewhat rough surface in order to provide solid footing, especially when wet.

The milk room and milking parlor will require a smoother surface and be sloped to drain for ease of maintenance and cleaning. Consult your Department of Agriculture for specific details.

To allow animals to feed when pens are cleaned and, therefore, empty of bedding, a foot/hoof support of 3 inch wide in the pen side is located 8 inch

higher than pen floor. This support helps goats to eat more easily by standing on it. This does not get in a way of cleaning the pen.

Framing

Walls are constructed of standard 2 x 6 framing, 24 inches on center. They should be insulated with fiberglass or other moisture-resistant (vapor barrier) insulation (R-19, for example) as necessary to maintain a temperature above freezing during the winter months. This keeps the bedding from freezing so that it can be cleaned as necessary. Here, external facing is sheet metal or corrugated iron screwed on batten (0.75 inch x 2.5 inch) (see article 90101 www.agrireseau.qc.ca/).

Inside walls can be covered with galvanized roofing or sheet metal up to a height of 5 feet in order to prevent the goats from nibbling on the walls. Ceilings should be insulated, as well.

For interior finishing, battens, polyethylene film and fiber glass or other materials make up the ceiling. The global R-value of the roof is about 5.2 (see article 90101 at www.agrireseau.qc.ca/). If the interior finishing is constituted of material that transmits heat or cold, such as sheet metal or plastic facing, a material should be added in the internal side to prevent condensation.

The roof has a slope of 1 in 2.4 (5 in 12). It is constructed with scissor type rafters for the main building and conventional triangle rafters for other areas. They are made according to the weather condition with 1.5 inch x 2.5 inch battens according to contractor; the metallic covering has a caliber 26 or 28. Because the ridge of the roof is higher than other rooms, certain elements have to be strengthened to support large quantities of snow.

Note that rafter sizing, construction, and roof slope will be mandated by local codes, weather conditions, and snow load. Please consult an engineer or licensed builder for guidance.

Manure Management

Accumulated manure is managed in solid form and this method assumes the use of 4 inches of absorbent material, such as sawdust, as a base on the pen floors, with the daily addition of litter or straw. The sawdust ensures comfort for the goats and makes removal of the bedding easier. The daily volume of manure produced, including the litter, represents approximately 0.22 cubic feet per day for an adult goat.

The pen floors, which are 16 inches lower than the alley floors, allow for a manure accumulation of two to three months in order to avoid cleaning during the winter months. The pen floors should not be any lower than this in relation to the feed alleys; health problems could develop if the bedding pack is low, and the goats must strain to get at the forage.

The manure is managed in liquid form in the nursery. Under a raised slatted floor of the kid pens, the areas are cleaned by scraping the manure into a gutter. Kids with an average weight of 22 pounds produce a daily volume of 0.13 gallon (0.02 cubic feet) of urine and manure. The wash water from the milk house and parlor washings (21–22.5 gallons per milking) is mixed with the nursery manure, and both are pumped or flow by gravity outside into a sealed tank with a 250-day storage capacity.

Artificial Lighting

Minimum artificial lighting in the goat barn should be 10 foot-candles (100 lux) at eye level. Twenty foot-candles (200 lux) is recommended for out of season light treatment at eye level, in the milking parlor at udder level, and in the milk house. Maximum lighting efficiency is obtained with fluorescent or halogen-type lights although other light types may also be used. White or light-colored walls and ceilings are recommended to improve light reflection. Other lighting types could be used; consult a specialist.

Ventilation and Heating System

Main Barn

During winter, temperature should be between 50° and 60.8°F (10–17°C) and humidity be maintained under 80%. During the summer, the temperature should not exceed 80°F (27°C). In order to

control lighting cycles for out of season breeding treatment, automatic ventilation is preferable. Fans placed at the bottom of the insulated chimneys in the center of the building draw the moist and hot air out of the building. Air inlets located in the outside walls provide fresh air. (These air inlets are shown in article 90312 at WWW.AGRIRESEAU.QC.CA/) Air inlet panels measuring 4 feet x 8 feet add ventilation during the hottest months. These open automatically but can be opened manually, as well.

Variable-speed fans provide a minimum turnover rate of 1.5 air changes per hour (0.05 cubic feet per second for this barn) and a maximum turnover rate of 12 air changes per hour (0.88 cubic feet per second) in order to maintain correct humidity levels. (Note: This is based on heat and moisture produced by a 132-pound, average-sized goat.)

Ventilation is properly maintained by an electronic regulator that controls two sectors of the barn independently. The air inlets and fans on each of half of the building are independently controlled. For each sector of the barn, it is a good idea to place four to six separate thermostats 10 feet from the walls and 6.5 feet above floor level. This arrangement provides a more precise reading of temperature than only one thermostat.

Natural ventilation can also be used if you do out-of-season breeding. However, you must have a separate building or area where you can control light and dark periods.

The relatively high metabolism of goats enables you to maintain the appropriate temperatures when the main barn is at full capacity. However, when cold weather sets in, a 72-kilowatt (15,000-Btu/hr) heater may be needed to maintain temperature. An 8-kilowatt (2,400-Btu/hr) heater is used in the nursery. They may be either propane or electric and are best mounted from the ceiling. A dedicated outdoor air inlet and vent must be provided for the combustion gases if you are using a propane unit. Installation of propane units should be done by a licensed professional and in accordance with local laws and regulations. Data here is provided for a Quebec climate; heating requirements may vary for your local weather conditions.

Kid Area and Milking Parlor

Ventilation and heating for the kid area and milking parlor are illustrated in Figures A4.7 and A4.8. Other alternatives can be used, however; consult an agricultural engineer or HVAC contractor.

A 59-foot-long, 2-foot x 2-foot square, insulated air duct divided into two longitudinal sections provides fresh air to the milking parlor and nursery. The air duct is insulated with 1½-inch-thick Styrofoam inside ⅜-inch plywood.

Two air inlets with adjustable covers located near the milk house, milking parlor, and nursery provide fresh air in warm weather. The covers are screened with ½-inch mesh hardware cloth to keep rodents and birds out and are covered with insulated panels during the winter months. In cold weather, a 2-inch cutout (with adjustable flap or baffle) in each section of the duct provides adequate inlet air.

Nursery

One or two thermostatically controlled fans located on the wall 15 inches below the ceiling pull stale air out of the building and provide from 1.5 to 20 air exchanges per hour. Fan capacities for this installation are 2.1 cubic feet per second minimum and 29 cubic feet per second maximum.

A 6-inch longitudinal and 3-inch wide air inlet is located in the ceiling with a flap (see article M-9750 at WWW.AGRIRESEAU.QC.CA/). See Figure A4.7.

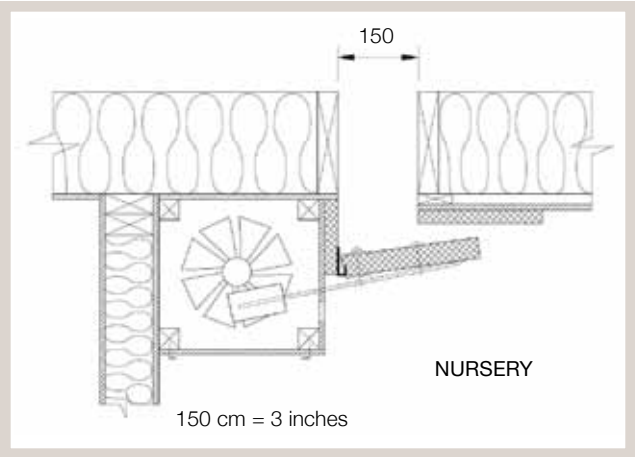


Figure A4.7 Air inlet in nursery ceiling.

Holes 1.5 inches in diameter spaced 24 inches apart in the air duct provide 1.5 to 2 times the required minimum recirculated air flow. An 8-inch-diameter variable-speed fan blowing air over a 3,000-watt heating element in this 12 x 12-inch duct pushes heated air into the nursery. A second thermostatically controlled fan in the nursery distributes the heated air and has its own 2,000-watt heating element. Together, they provide 1,500 BTUs per hour of heat into the nursery.

Milking Parlor

One or two thermostatically controlled fans located on the wall 15 inches below the ceiling provide air circulation, as in the nursery (see Figure A4.8). A 6-inch-wide longitudinal air inlet located in the ceiling with an air flap blows fresh air uniformly into the holding area and the milking parlor (see article 90312 at WWW.AGRIRESEAU.QC.CA/). A small supplemental heater may be necessary to provide heat to the parlor.

Nursery and Milking Area

This wing is attached to the main barn and includes the milk house, generator room, nursery, and holding area (see Figure A4.9, page 151).

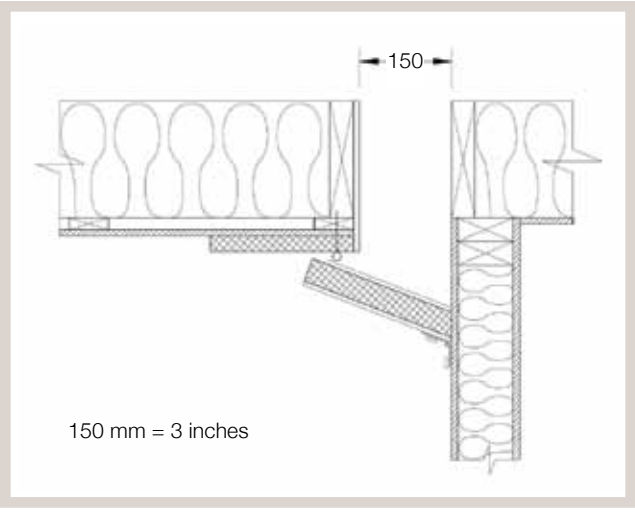


Figure A4.8 Air inlet on ceiling of milking parlor.

Milk House

Milk house design for this Quebec dairy facility is provided in article 20508 named "Laiterie de Ferme" from MAPAQ (Agency of Agriculture, Fisheries and Food of Quebec) at WWW.AGRIRESEAU.QC.CA/). Milk house design is rigidly regulated by each state or provincial authority. Consult your local Department of Agriculture prior to design and construction for guidance.

Milking Parlor

The double-sided milking parlor deck is 3 feet above the pit floor. Decks are 18 feet long, and the parlor can handle 36 goats, with the same number waiting in the holding area. The slope of the decks can vary from 5% to 10% from entrance to exit. It helps to align goats, heads up, coming into the parlor. The 6-foot-wide pit allows enough space to hide and protect pipelines. Milking parlor design and construction are regulated by the local Department of Agriculture and must be approved in advance of construction.

Nursery

A 520-square-foot room can hold approximately 110 kids from birth to 2 months old. The floor is perforated (or on expanded metal) and raised 12 inches above the floor, allowing adequate room for a scraper below that will collect the manure into a gutter cleaner for removal.

Feed and Bucks' Area

A 38 x 32-foot wing is connected to the main barn by a corridor that serves to distribute hay and grain. This room can be used to thaw round bales in winter. This part of the barn can house up to eight bucks and should be ventilated and heated as well. For more information, consult "Le guide Chèvre" (1998 Publication AR001, Conseil des Production Animales du Québec, ISBN 2-89459-034-2) and an engineer from MAPAQ or a consultant in agricultural engineering.

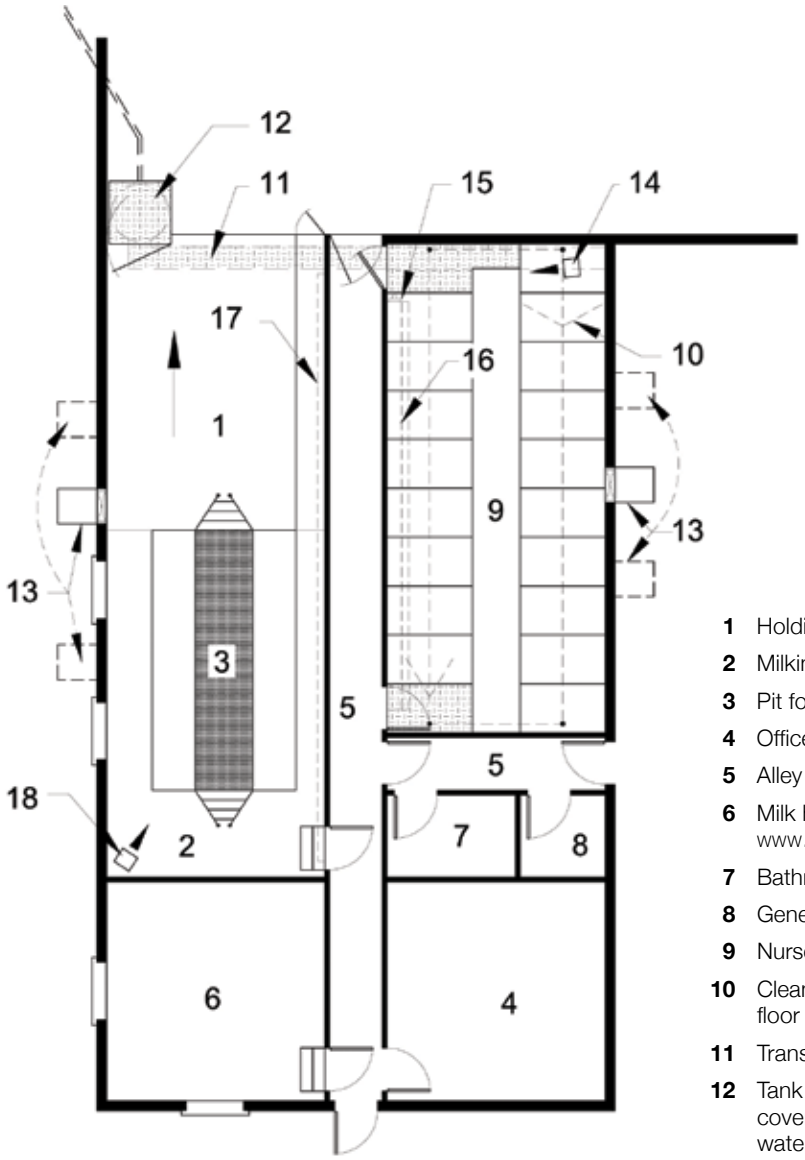


Figure A4.9 Barn floor plan for nursery, milk house, milking parlor and office area

1 Holding area
2 Milking parlor
3 Pit for people
4 Office
5 Alley
6 Milk house (see report 20508 at www.agrireseau.qc.ca/)
7 Bathroom
8 Generator and electrical room
9 Nursery
10 Cleaning system under perforated floor
11 Transversal gutter
12 Tank collecting cleaning water with cover. Cleaning and contaminated water is driven towards a small tank or in the manure
13 Cleaning system under perforated floor
14 2000 watts areo-thermal fan
15 Speed controlled fan with an 8-inch diameter
16 Air duct with 1.50 inches diameter holes every 24 inches and an air inlet trap
17 Air inlet going to milking parlor and holding area
18 3000 watts areo-thermal fan in the milking parlor

Endnotes

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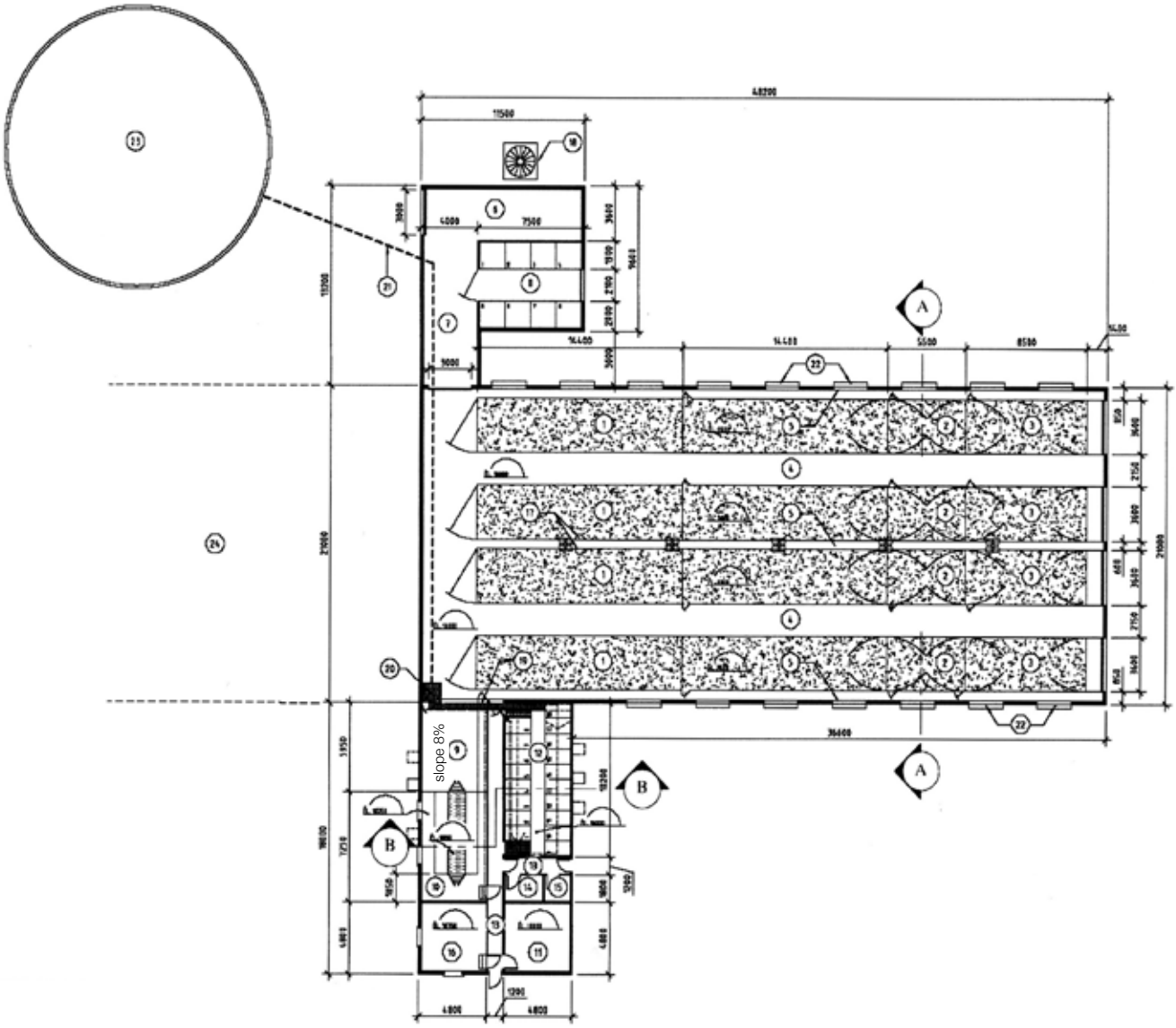
5. Laurent Demers, Engineer and Agronomist, Central Quebec Regional Department of MAPAQ.



1 Pen for 72 goats
2 Pen for about 25 dry goats
3 Pen for about 30 doelings
4 Feed alley
5 Walking alley for goats
6 Feed storage
7 Alley
8 Bucks area
9 Holding area
10 Milking parlor
11 Office
12 Nursery for about 110 kids (0–2 month)
13 Walking alley
14 Bathroom
15 Electrical area
16 Milking room
17 Water bowls
18 Silo
19 Gutter gathering cleaning and contaminated water with a slope
20 Tank gathering cleaning and contaminated water
21 Pipeline that conduct contaminated water towards a tank or manure pile
22 Lateral panels for ventilation of 4 x 8 feet
23 Tank
24 Potential extension

Specifications:

This document is paperwork for agricultural purpose.

Its use requires particular conditions adaptation.

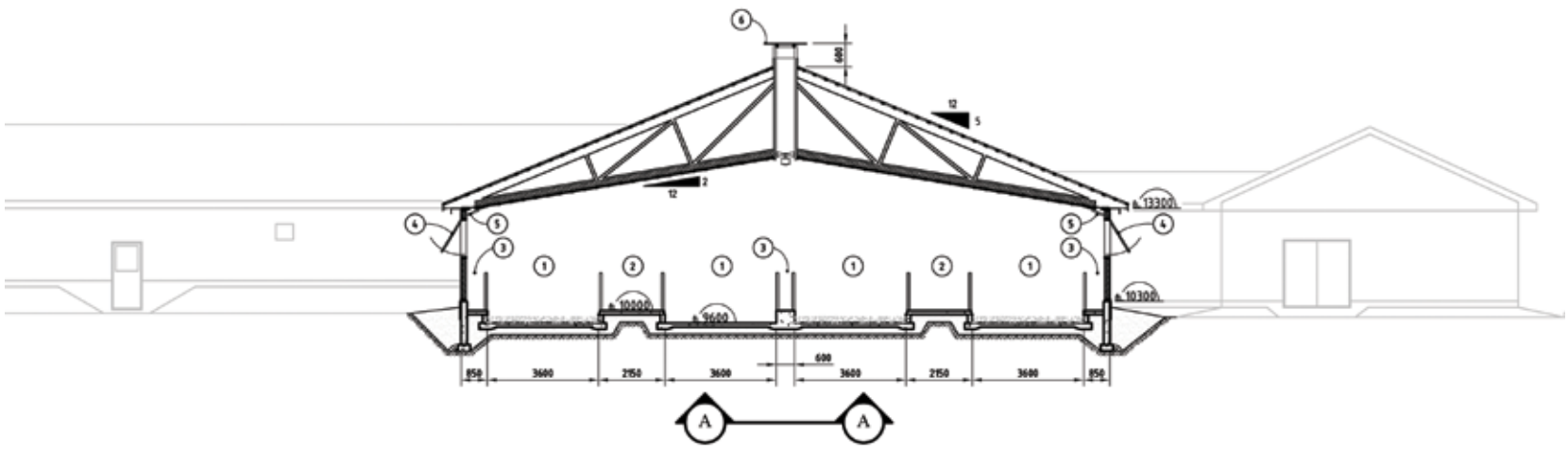
In that case, agricultural engineer is required.

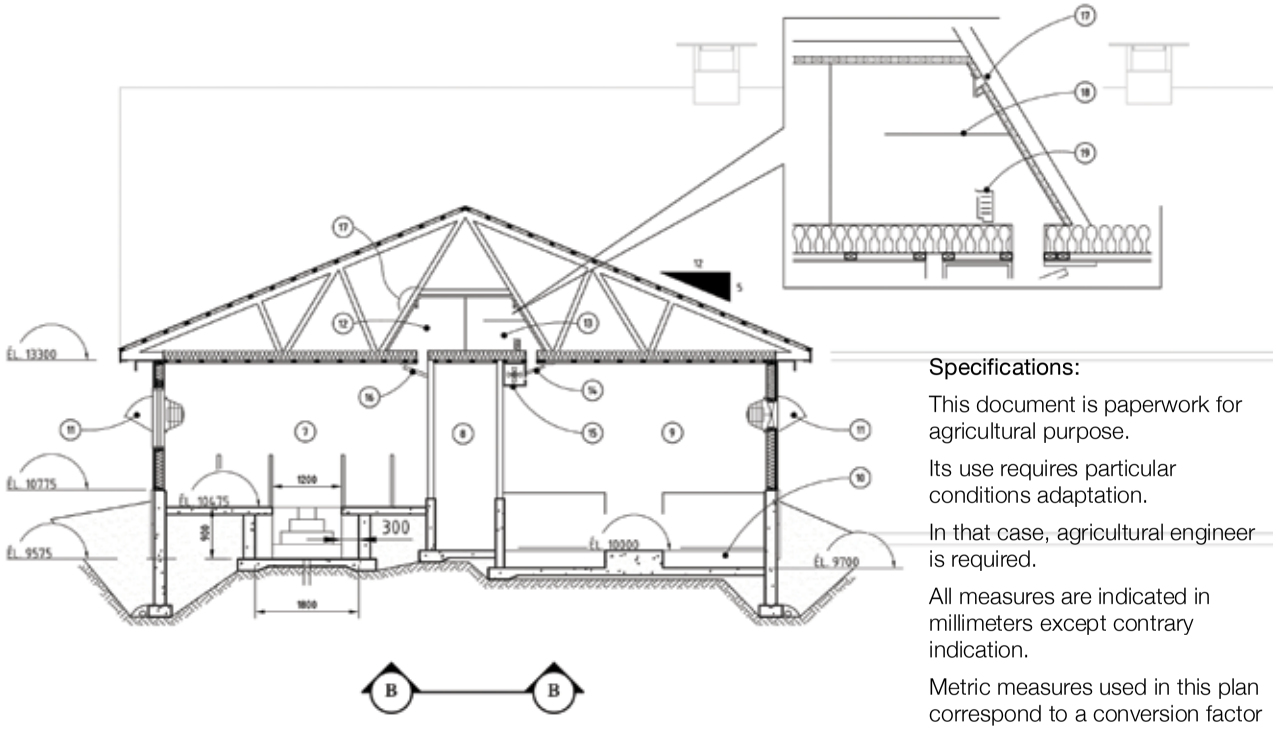
All measures are indicated in millimeters except contrary indication.

Metric measures used in this plan correspond to a conversion factor of 300 mm = 1 foot or 25 mm = 1 inch

Figure A4.10

Figure A4.11





1 Pen floor
2 Feed alleys
3 Walking alleys for goats
4 Lateral vented panels
5 Air inlet on the wall on both sides (see paperwork 90312)
6 Isolated air extraction chimney and a fan at its base
7 Dock for milking
8 Walking area
9 Nursery
10 Cleaning system underneath perforated floor
11 Exhaust fan controlled by thermostat
12 Duct blowing air (holding area and milking parlor)
13 Air duct blowing fresh air in the nursery. A 3000 W plywood helps to warm air before the nursery
14 Air admission trap
15 Air

Specifications:

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In that case, agricultural engineer is required.

All measures are indicated in millimeters except contrary indication.

Metric measures used in this plan correspond to a conversion factor of 300 mm = 1 foot or 25 mm = 1 inch