On-Farm Grain Storage and Drying Considerations

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Extension

On-Farm Grain Storage Planning Considerations

A number of factors that ultimately affect the profitability of on-farm storage facilities are difficult to include in a budgeting framework. Grain handling and storage facilities require careful planning. Normally, storage capacity can be doubled without any major problems. However, tripling the storage capacity requires careful planning before construction of the first bin. Most producers want to expand their facilities over time, as capital becomes available, rather than borrowing large sums to construct a total system. Therefore, planning becomes all the more critical, as it is easier to change things on paper than after construction begins.

All systems have bottlenecks that limit the throughput of the operation. Grain handling and storage components are part of the overall harvesting system. The storage facilities should not create bottlenecks that cause less than optimum performance of the combine(s) or truck(s). It is important to recognize where some of the bottlenecks can occur during harvest and plan to minimize them. The following are nine common bottlenecks in the harvesting system:

1. Truck’s inability to maneuver around storage equipment.
2. Mismatch of harvesting, trucking, and unloading systems.
3. Distance from the field to the storage site.
4. Auger movement and positioning between bins.
5. Lack of drying capacity or storage for high-moisture grain.
6. Lack of preventive maintenance.
7. Lack of adequate all-weather roads and driveways.
8. Lack of conveniences for weighing trucks across scales.
9. Inadequate temporary storage ahead of cleaner or dryer.

Each of these bottlenecks can be avoided. However, in many cases, poor planning can result in at least three or four being built into the system. Thus, the producer must either make additional investments to correct the problem or live with it. The following is a discussion of factors that can alleviate or prevent the bottlenecks.

Site Selection

There are three main components of site selection. The site must be accessible, have electricity, and be well drained.

Accessibility includes adequate entrances off county or state roads and space around the bins. A minimum of 40-foot access off of a main road is required. A square open area of ¼ to ½ acre is needed for trucks to be able to turn around without backing long distances. Semi-trucks require a minimum turning radius of 55 feet or a diameter of 110 feet.

Electricity is the second requirement. Single- phase electricity generally limits the largest motor to 10 horsepower. This is normally adequate for most drying fans, but could limit the capacity of the handling equipment or high-temperature dryers (HT dryers). Three-phase electricity is preferred for high-volume facilities and those that are planning on incorporating HT dryers, electrically driven augers, or pneumatic conveyors. A phase converter, which converts single-phase to three-phase, may be used. Producers need to work with electrical suppliers to make sure the electrical distribution lines can carry the load, adequate lines are installed, and allowances are made for future expansion. It is recommended that power lines be at least 100 feet from the grain bins, with underground lines used to bring power into the sites.[1]

The site's physical attributes is the third factor to consider. Most on-farm storage facilities can be constructed on a site of 1 to 2 acres. The storage bins should be located at least 50 feet from any building, although 100 feet is desirable. Groundwater should be a minimum of 10 feet below surface, with 15 to 20 feet preferred. Most pits used with legs are in the ground 8 to 10 feet, with large capacity pits exceeding 15 feet. The surrounding area should drain away from the site, with diversions constructed if necessary. Sump pumps never work as well as planned because of lack of maintenance and plugging of drains.

Under no conditions should runoff from surrounding areas drain through the grain handling facility. The driveways and bin pads should be 12 inches higher than the surrounding terrain to minimize erosion or water problems into pits or bins. Another site factor to consider is nearby residences. Prevailing winds can carry chaff, foreign material, or debris toward residences. Fan noise also can be a problem if the fans are installed on the residence side of the bin. It is recommended that bins be located 200 feet from residences. A professional engineer may be needed for site preparation to ensure the soils will carry the dead loads created during storage.

Bin Selection

Each producer should determine how much storage is needed based on annual harvest, marketing potential, distance to elevator, and capital availability. The largest bin on the farm generally should not exceed 50 percent of the largest crop harvested. Multiple bins allow more flexibility than one large bin. Also, if a portion of the grain goes out of condition, the entire harvested crop is not jeopardized.

A minimum number of bins probably is one per crop per season. Therefore, someone who raises corn, grain sorghum, and soybeans should have at least three bins. As was demonstrated in Figure 4, larger bins normally have a lower initial investment, as compared to multiple smaller

[1] Minimum guidelines are outlined by the National Electrical Safety Codes for installation of power lines near grain bins and storage facilities.

bins, but lack long-term flexibility. Bins used primarily for seed storage should be limited to 2,000 to 3,000 bushels per bin and preferably have a hopper bottom. For grain storage, bins continue to get larger, with 100,000 bushel and larger bins becoming more common. However, it is important to recognize the increased importance of managing the grain quality and condition in these large bins.

Drying Systems

Options available for in-bin drying systems include natural-air drying; low-temperature drying (LT); layer drying; batch-in-bin drying; dryeration; LT with recirculator, stirrers, or continuous flow drying. LT drying systems, as a minimum, require a full perforated floor, a fan capable of providing 0.75 cubic feet of air per minute (cfm) per bushel, and a burner unit. At least 25 to 50 percent of the total storage capacity should be equipped for low-temperature drying. Additional drying capacity can be obtained by installing a recirculator, stirrer or continuous flow drying system within a bin. Once storage capacity exceeds 50,000 bushels, installation of a HT dryer should be considered. Under no condition should a bin be constructed without having an aeration fan installed (only moves 0.1 to 0.5 cfm/bu as compared to 0.75 or greater cfm/bu with a drying fan). The sidewall depth should be limited to 16 feet or less if the bin is used for LT drying. The bins used strictly for storage can have deeper depths. Publication MWPS-13, Grain Drying, Handling and Storage Handbook, is a resource on various drying systems.

Bin Layout

Bin layout has two primary shapes: straight line or circular. Bins located in a straight line are easier to expand and incorporate into a vertical bucket elevator at a later date. The main disadvantage is with filling the bins with augers. Each time a bin is filled, an auger has to be moved. With increased auger capacities, a horizontal auger across the top of a row of bins enables an inclined auger to be set up once without having to move it each time a different bin is filled. Circularly arranged bins require careful planning.

As the auger is rotated around a pivot point, it must be able to fill each bin. The auger is mounted such that the wheels rotate around the inside of bins and can be manually moved between bins. It is the opinion of the authors that straight-line bin arrangements are preferred to circular over the life of the system.

Other Considerations

Grain facilities are usually at one central site. Advantages to a central site include more efficient use of equipment, potential to automate equipment, less road construction and maintenance, more security, and central storage of records and grain quality equipment. However, some landlords may require their grain to be stored elsewhere, requiring multiple storage sites. Also, if the farm is ever sold, it may be easier to sell two smaller storage facilities than one large unit.

For long-range planning, it is better to plan a central site and then subdivide at a later date, if necessary. It is often easier to downsize than to upsize the system.

Bins should have a minimum of 2 to 3 feet between them with 6 feet preferred if handling equipment must pass between bins. All mechanical systems eventually break down, accessibility or future repairs should be considered in the planning phase. The extra space between bins normally will not result in a noticeable difference in the cost of the handling equipment. The area around the bins should be treated to prevent grass and weeds from growing. Vegetation often serves as a home for rodents and insects and is difficult to maintain. Bins should have factory-installed ladders inside and outside, along with a man door and fill port. Other desirable accessories include roof vents (a must if fans are eventually to be automated), grain spreader, and temperature monitoring systems. Appropriate handling equipment for emptying the bin must be purchased and installed as the bin is erected.

Two rows of bins should be spaced a minimum of 20 feet apart. If a leg, dryer, scales, or feed processing center ever are installed, there is still adequate room for a driveway, along with these components. Roads should be crowned to provide adequate drainage for all-weather use. Planning bin layout should include consideration for the 110-foot diameter turning circle required by semi-trucks.

Grain is handled on-farm with augers, bucket elevators (legs), or pneumatic conveyors. Once the capacity exceeds 100,000 bushels, a leg should be considered to provide flexibility in handling, blending, and turning of grain. High-temperature dryers should have smaller leg or auger arrangements to load and unload the dryer and not depend on the main grain handling equipment. Careful planning is required to make sure all of the components have at least equal capacity. As a planning guide, each time grain is transferred between handling equipment, the second piece of equipment should have a 10 to 25 percent higher capacity than the first. This will prevent bottlenecks within the grain handling system. The capacity of holding tanks ahead of a dryer or cleaner should equal 2 to 4 hours of combine harvesting capacity. Handling equipment can be eliminated if holding tanks are placed in the air and gravity feed.

The capacity of the handling equipment should be based on the desired truck unloading time. A 1,000-bushel truck unloading in 10 minutes requires the handling equipment to have a minimum capacity of 6,000 bushels per hour (bph). If a pit is used, then the unloading time is based on the expected time between loads received. Changing the unloading time from 10 to 15 minutes reduces the handling equipment capacity from 6,000 bph to 4,000 bph. A new facility using a bucket elevator should have a minimum capacity of 5,000 bph.

Material adapted from Kansas State University Publication - MF-2474 – The Economics of On-Farm Storage - http://www.ksre.ksu.edu/bookstore/pubs/MF2474.pdf

Appendix – Figures of storage system layouts

Figure A1. *50,000 bushel system.*

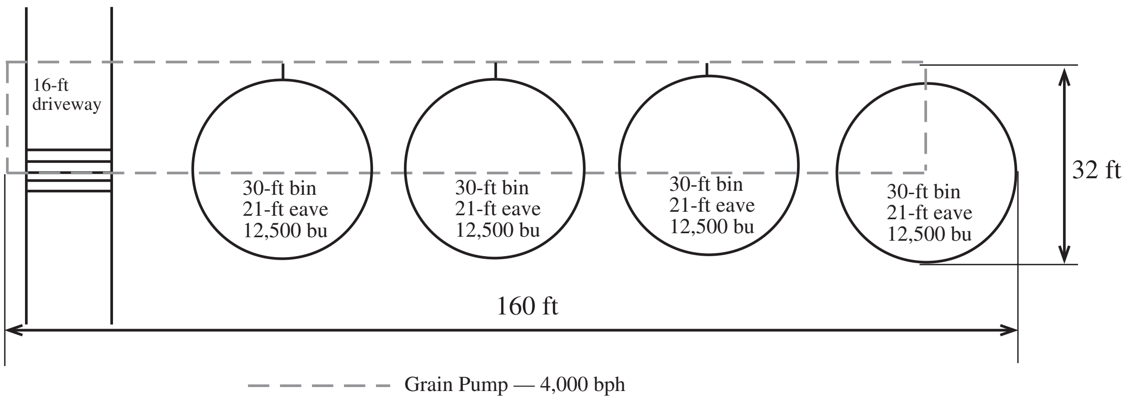


Figure A2. *95,000 bushel system.*

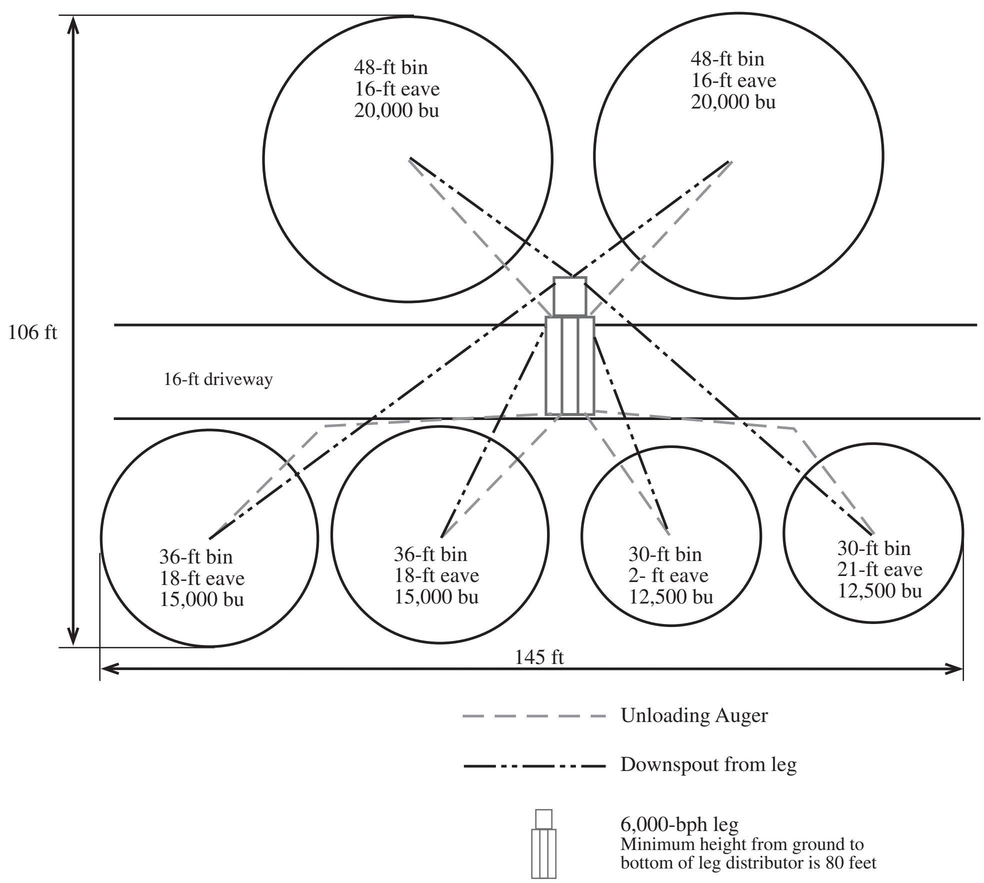


Figure A3. *163,100 bushel system.*

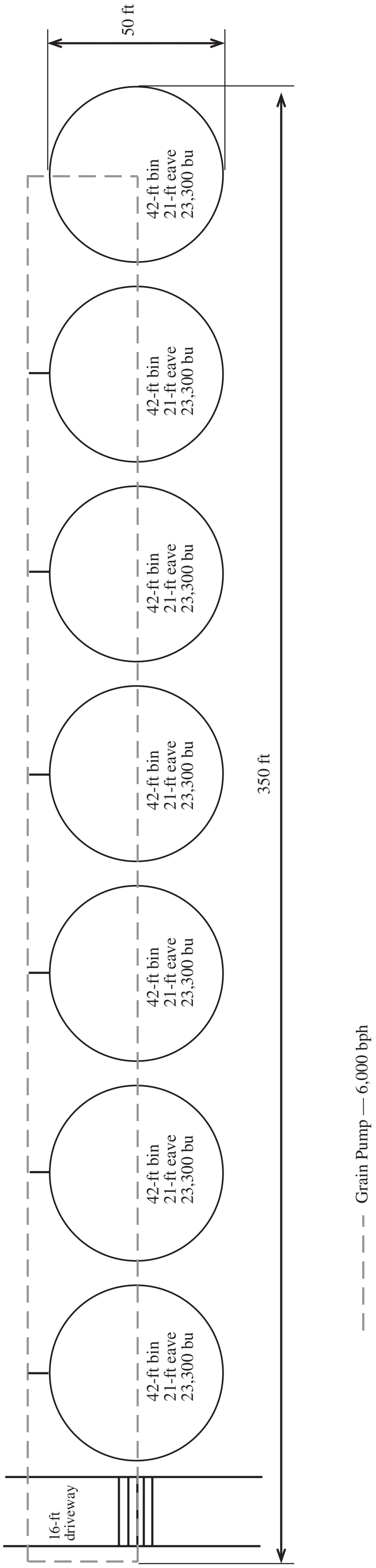
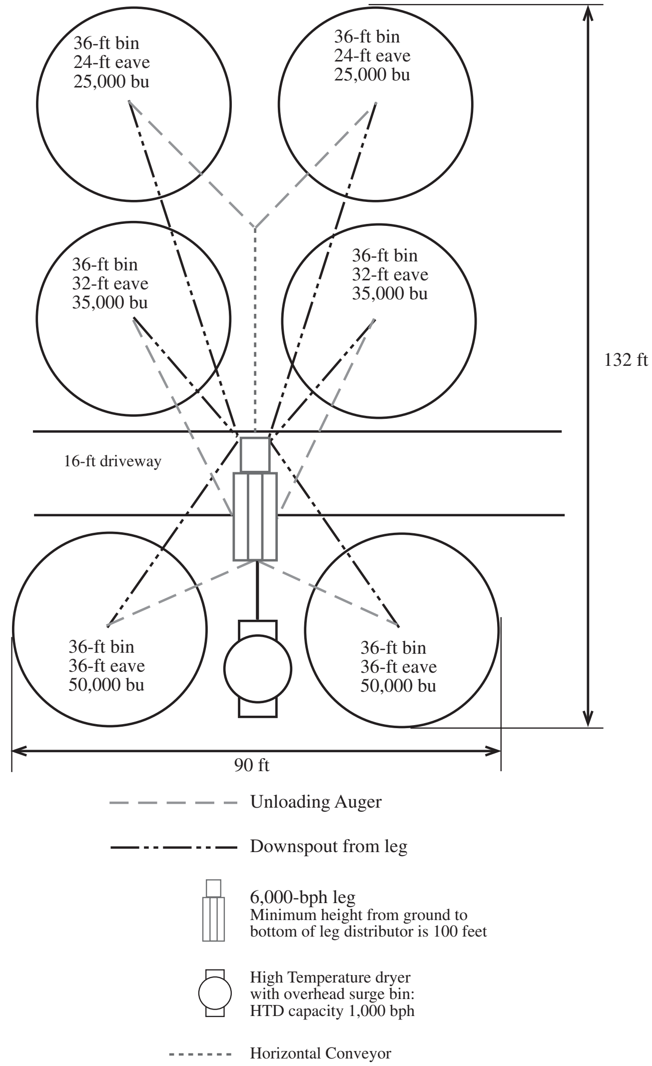


Figure A4. *220,000 bushel system.*



Your Storage Facility

Scale: 1 inch = ____________

Calculating Combine Efficiencies for Grain Storage Considerations

This example utilizes a combine with an 8-row corn head and 280 bushel grain tank with a discharge rate of 2.8 bushels/hour. The area you need to harvest per season is 2000 acres. The corn is yielding 200 bushels/ac and is in ½ mile rows. The maximum speed in the field is 5 mph, and average travel distance to the trucks for offloading is 1/4 mile. The turn time at the end of field rows is 20 seconds. The combine travel speed to offload is 5 mph when full and 6 mph when empty. A single 1000 bushel grain cart is available with the same travel speeds as the combine. The unloading rate of the wagon is 500 bushels/min. A maximum of four, 1000 bushel trucks are available to move grain to the elevator which is 15 miles from the field and the average speed of the truck is 30 mph. The unloading time at the elevator is 30 min.

Determine the Theoretical Field Capacity, Effective Field Capacity, Field Efficiency, Operating Material Capacity, and Effective Material Capacity under the following conditions below (Part 1, 2, and 3).

First need to calculate,

Theoretical Field Capacity = Speed x Width of Harvest
= 5 mph x 20 ft x 5280 ft/acre x 1 acre / 43560 square feet = 12.12 acres/hour

Operating Material Capacity = Theoretical Field Capacity x Yield
= 12.12 acres/hour x 200 bu/acre = 2424 bu/hr

Next calculate, Field Efficiency % = (Total Time – Wasted Time) / Total Time x 100

To calculate Total Time will need to first calculate Time Harvesting = Distance Traveled / Speed

Distance Traveled = 2000 acres x 43560 sq ft/acre x 1/20 ft (8 row corn head) = 4,356,000 feet x 1 mile/5280 feet = 825 miles

Time Harvesting = 825 miles / 5 mph = 165 hours

Time Turning on the End Rows

Number of Turns = 4,356,000 total feet traveled / 2640 ft (1/2 mile rows)
= 1650 turns

Time Turning = Number of Turns x Time During Turns
= 1650 turns x (20 seconds / turn) = 33000 seconds x (1 hr / 3600 sec)
= 9.17 hours

Time Unloading

Time to truck = 0.25 miles / 5 mph = 0.05 hours

Time from truck = 0.25 miles / 6 mph = 0.0417 hours

Time unloading grain tank = 280 bu / 2.8 bu/sec x (1 hr / 3600 sec)
= 0.0278 hours

Total Time for One Unloading = 0.1195 hours

Number of unloadings = 2000 acres x 200 bu/acre / 280 bu/dump = 1428.57 dumps

Total Time Unloading = 0.1195 hours x 1428.57 dumps = 170.71 hours

Field Efficiency % = (Total Time – Wasted Time) / Total Time x 100
= ((165 hrs + 170 hrs + 9 hrs) – (170 + 9)) / (165 + 170 + 9) x 100
= 48%

1). The grain wagon is not used, and the combine unloads at the trucks. (For this ignore trucking time and assume that the trucks are capable of transporting all grain harvested.)

With a field efficiency of 48%,

Effective Field Capacity = 12.12 acres/hour x 0.48 = 5.8 acres/hour

Operating Material Capacity = 5.82 acres/hour x 200 bu/acre = 1164 bu/hr

2). The grain wagon is used, and the combine unloads on the go. (For this ignore trucking time and assume that the trucks are capable of transporting all grain harvested.)

One will first need to figure out if there will be any down time waiting for trucks or grain cart.

Check of timing of grain cart:

Time to and from truck same as calculated for combine
= 0.05 + 0.417 = 0.0917 hours x 60 min/hr
= 5.5 minutes travel time for grain cart

Time to unload grain cart
= 1000 bushels / 500 bu/min = 2 minutes

Total time for grain cart would be 7.5 minutes

Time to fill grain tank on combine = Tank capacity / Operating Material Capacity
= 280 bu / 2302 bu/hour = 0.1216 hour x 60 min/hr = 7.3 minutes

Note: the Operating Material Capacity of 2302 bu/hour was calculated utilizing a effective field capacity of 11.51 acres/hour (field efficiency was 95% with only wasted time being time turning on the ends of 9 minutes)

So one would have to wait .2 minutes per grain cart x 400 grain cart loads = 80 minutes total wait time

This would improve field efficiency of the combine as calculated:

Field Efficiency % = (Total Time – Wasted Time) / Total Time x 100
= ((165 hrs + 9 hrs + 1.33 hrs) – (9 + 1.33)) / (165 + 9 + 1.33) x 100
= 94%
Effective Field Capacity = 12.12 acres/hour x 0.94 = 11.4 acres/hour

Operating Material Capacity = 11.4 acres/hour x 200 bu/acre = 2281.14 bu/hour

3). The grain wagon is used, and the combine unloads on the go. Include the effect of transportation in this analysis.

Time to unload a truck = 30 miles round trip / 30 mph = 1 hour travel time and 30 minutes to unload = 90 minutes total time to unload a truck

Time to load a truck or grain cart = 1000 bushels / 2281 bu/hour = 0.43 hours x 60 min/hr
= 25.8 minutes

(25.8 minutes x 3 trucks) + 25.8 minutes per grain cart = 103.2 minutes

4th truck is finished uploading and back to the field in 90 minutes

So one would not have to wait on a truck, there is 13.2 minutes to spare.

This would keep Effective Field Capacity at 11.4 acres/hour with an Operating Material Capacity of 2281 bu/hour as in part 2.