

# Seasonal High Tunnel System for Crops

## Interim Conservation Practice Job Sheet 798

### Where used



A seasonal high tunnel system (SHTS) may be used where existing specialty commodity crops are grown in open field conditions, and extension of the growing season is needed due to climate conditions.

Commercially available high tunnel structures are made in numerous widths and lengths and types (round, arch, etc.). High tunnels are constructed of metal frames and covered with a layer of polyethylene. The larger the system, the more thermal mass is stored, and a single layer of poly cover may provide one hardness zone of protection while a second row cover may provide a second zone of protection.

Ventilation is achieved by opening the roll-up sides and ends or removing the cover. The end walls are generally framed-in to create a door and ventilation area, although doors can be designed to spring open for the warm season.

Plants in the SHTS rely on irrigation water, applied either by hand, drip or sprinkler irrigation, etc. and are normally irrigated daily. An average of 2 to 5 times as much irrigated water may be used on crops in a high tunnel

compared to an outdoor system, unless roof runoff water is collected and used on the crops.

Fertilizer and pesticide use is usually lower because there is no excessive leaching in the soil profile, from rainfall, leading to improved water quality.

The SHTS spans several crop rows which allow for full crop maturity. The tunnel should be high enough to accommodate small farm equipment and not hinder plant growth. Tomatoes, bush crops or crops requiring trellises may need 4 to 6 foot sidewalls to prevent shading of the light transmission.

Most structures are installed on north-south axis to maximize summer light. When the growing season is expected to extend into winter months, consider orienting the high tunnel along a more east to northeast or west or southwest axis (reference "The Passive Solar Energy Book" by Edward Mazria and "High Tunnels" by Ted Blomgren and Tracy Frish).

Structures placed perpendicular to prevailing winds typically receive the most damage, so when strong seasonal winds are a concern, consider placing near a windbreak of trees, shrubs or fabricated material to moderate or redirect the wind (reference Windbreak / Shelterbelt Establishment (380)).

### Criteria

The type, shape and height of a SHTS selected shall be based on the

- crop(s) planted, row width, bed width and number of rows (min. 3) and height.
- length of seasonal extension required for plant protection.
- availability of a flat to mild slope site. Do not place SHTS on slopes greater than 4% (parallel to the length or 3% (perpendicular to length)). The manufacture shall approve placement of SHTS on slopes greater than 3% and provide additional structural components (i.e. length of supports, posts, cover extension to the ground, etc.).

- height extension of farm equipment (minimum of 6 feet high) used inside the SHTS.
- SHTS footprint (minimum of 20' wider and longer than the selected SHTS).
- location and proximity to other elements (trees, buildings, hillsides, etc).
- design for heavy snow and wind loads where this is a concern.

A seasonal high tunnel shall

- not be a greenhouse, nor grow crops in containers, pots, on benches or tables.
- not be placed in the 25 year-24 hour floodplain.
- protect the ground from surface water runoff and erosion.
- be covered by 6 mil polyethylene clear film (4 year minimum warranty).
- have a documented year-round water source, such as a river, stream, pond (min. 1.1 SF surface area per SF of SHST with a minimum 6' depth with adequate watershed and/or spring), irrigation well (minimum of 0.005 GPM per SF of SHTS) or municipal water (PSD notification).
- have a steel constructed frame
- have a maximum four (4') rafter or bow spacing
- have a wind bracing kit or have heavy duty post supplied by a reputable manufacture of SHTS.
- be protected from heavy snows or high winds when they are expected to compromise the structure.
- have manufactured supplied ground posts installed a minimum of 24" or 6" below the frost depth, whichever is greater.
- have purlins connected by cross connectors to the bow, for added strength.
- have roof runoff (10 year -5 minute storm (0.55") directed away from the SHTS to a stable outlet .
- have a minimum length to width ratio of 2:1 and a maximum length to width ratio of 4:1.
- be on a site with productive soils.

- ensure drainage away from the structure.
- be on a site with adequate set back distance from hills, trees or buildings (minimum of 2.5 to 4 times SHTS height) to avoid unnecessary shadows..
- have cemented corner end post, as a minimum, and optimally every other post for structures greater than 20' wide or 20' long.
- be located and aligned based on the landowner's documented decision.

There are many manufactures of SHTS. The width of the SHTS allows it to be categorized as small, medium or large.

#### Seasonal High Tunnel Structure (small)

In addition to the above CRITERIA; small, semi permanent or portable SHTS, often referred to as cold frames, are 12' to 14' wide, 900 SF or less and

- extend the growing season by 1 to 2 months.
- can remove the cover before, during or after the growing season.
- have a minimum 17 gage galvanized steel tubular steel 1.315" diameter frame.
- have a minimum of 2 purlins.

#### Seasonal High Tunnel Structure (medium)

In addition to the above CRITERIA; medium, SHTS are 15' to 20' wide, greater than 900 SF and less or equal to 1600 SF and

- extend the growing season by 3 to 4 months.
- have a minimum 14 gage galvanized steel tubular steel 1.66" diameter frame.
- have a minimum of 3 purlins.
- have heavy-duty ground post a minimum of 2.0' in the ground.



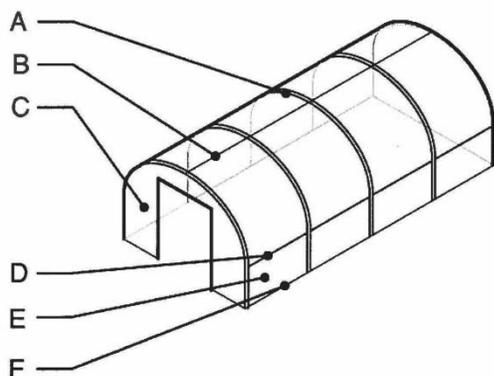
Seasonal High Tunnel Structure (large)

In addition to the above CRITERIA; large, SHTS are wider than 20' to 34' wide or greater than 1600 SF, and

- have a minimum 14 gage galvanized steel tubular steel 1.66" diameter frame for frames wider than 20' to 26' wide.
- have a minimum 13 gage galvanized steel tubular steel 1.90" diameter frame for frames greater than 26' – 34'.
- have a minimum of 5 purlins for SHTS wider than 20' and less than 28' or a minimum of 3 purlins and truss with every bow for SHTS 28" wide or wider.
- have heavy-duty in-ground post a minimum of three (3') in the ground.



Typical terms associated with SHTS are noted in the drawing below.



- A.) Rib, Hoop, Arch, Bow
- B.) Purlin , Ridgepole
- C.) End Wall
- D.) Hip Board
- E.) Side Wall
- F.) Baseboard

**Conservation management system**

Roof runoff water from the high tunnels or other nearby sources can cause erosion and ponding issues and require the application of other conservation practices such as Diversion (362), Roof Runoff Structure (558) gutters or gravel filled trench, Grassed Waterway (412), Surface Drainage - Field Ditch (607), Mulching (484) and/or Critical Area Treatment (342).

Roof runoff shall be planned by either installing a gutter system (supports designed by manufacturer) and meeting RRS (558) or a surface treatment area having a minimum 1% to a maximum 6% longitudinal slope and extending a minimum of 2' past the end of the structure. Runoff shall be diverted, away from the structure (minimum 2% slope) to prevent ponding near the structure foundation. Runoff can discharge into a Surface Ditch-Field Drain (607), Subsurface Drain (606) or stabilized area.

If gutters are not used to capture roof runoff, erosion may be prevented by installing

- a minimum 4' wide permanent vegetative area (CAP-342) for SHTS's 2178 SF or less, sloped, graded and having permanent vegetation.
- a surface treatment of course gravel (minimum 2' wide x 4" thick) underlain by geotextile such as AASHTO 57, AASHTO #3 or a poorly graded cobble (1"-3") free of fines, sand and soil. Crushed limestone shall not be used.
- a surface treatment of woodchips or mulch (Mulching (484), an average 4" thick x 2' wide placed on top of filter fabric or weed fabric when slopes are less than 2%.
- a permanent vegetated surface ditch (SD-FD (607)) with a stable outlet such as a vegetated "V" ditch that is 0.5' deep with 4:1 SS.
- a combination of the above or other runoff protective measures.

On expansive soils or bedrock, gutter downspout extensions or rock-lined extensions

shall extend a minimum of five (5) feet beyond the structure.

Practices, that address runoff protection, shall be planned and installed as a condition of installation of a high tunnel.

Other key practices are noted on the next page.

Additional practices should be considered as part of a conservation plan, such as nutrient and pest management, crop rotation, and heavy use area protection.

## References

WVU Extension Service: Construction of High Tunnels: Resources for Organic Farmers (<http://www.extension.org/article/18369>)

Cornell University High Tunnels ([www.hort.cornell.edu/hightunnel](http://www.hort.cornell.edu/hightunnel))

Penn State Center for Plasticulture, High Tunnels (<http://plasticulture.cas.psu.edu/H-tunnels.html>)

WVU Extension Service: Organic Vegetable Production Systems, Season Extension (<http://www.extension.org/article/18622>)

High Tunnel Raspberries and Blackberries, 2009, (<http://www.fruit.cornell.edu/Berries/bramblepdf/High%20Tunnel%20Production-2009%20rev.pdf>)

High Tunnels: “Using Low Cost Technology to Increase yields, Improve quality and Extend the Season” by Ted Blomgren and Tracy Frisch (<http://www.uvm.edu/sustainableagriculture/hightunnels.html>)

Season Extension: Introduction and Basic Principles

(<http://www.ces.ncsu.edu/chatham/ag/SustAg/SeasonExtensionOctober2005a.pdf>)

Hightunnels Website ([www.hightunnels.org](http://www.hightunnels.org))

Midwest Season Extension; Projects and Programs (<http://midwestseasonextension.org/programs.html>)

Salinization:  
“Salinity and Plant Tolerance”; Utah State University Extension;  
<http://extension.usu.edu/files/agpubs/salini.htm>.

Nitrates:  
Sideman, Eric PhD. “Nitrate Accumulation in Winter-Harvested Crops: A Growers’ Guide”, Main Organic Farmer and Gardener. June-August 1999, p 40-41

Cold Stress Physiology:  
“Responses of Plants to Environmental Stress”, Levitt, J., Orlando, FL: Academic Press. 1980

Temperature Management in High Tunnels”; Lewis Jett, PhD, WV Extension Service  
[http://www.hightunnels.org/PDF/JETT\\_High\\_Tunnel\\_Temp\\_Mgt.pdf](http://www.hightunnels.org/PDF/JETT_High_Tunnel_Temp_Mgt.pdf)

High Tunnel resources or structural suppliers (NRCS does endorse or recommend any manufacture): Agra Tech, Inc (Pittsburg, California) [www.agra-tech.com/](http://www.agra-tech.com/); FarmTek (Dyersville, Iowa) [www.farmtek.com](http://www.farmtek.com) (such as Gro-Max Gothic tunnels or Premium Round Style); Haygrove Tunnels (Elizabethtown, Pennsylvania) [www.haygrove.co.uk](http://www.haygrove.co.uk); Keeler Glasgow (Hartford, Michigan) [www.keeler-glasgow.com](http://www.keeler-glasgow.com); Rimol Greenhouse Systems (Hooksett, New Hampshire) [www.rimol.com](http://www.rimol.com); Poly-Tex Inc. (Castlerock, Minnesota) [www.poly-tex.com](http://www.poly-tex.com) are located in the area. Reference (<http://www.hightunnels.org/resources.htm#StructureSuppliers>) for additional information.

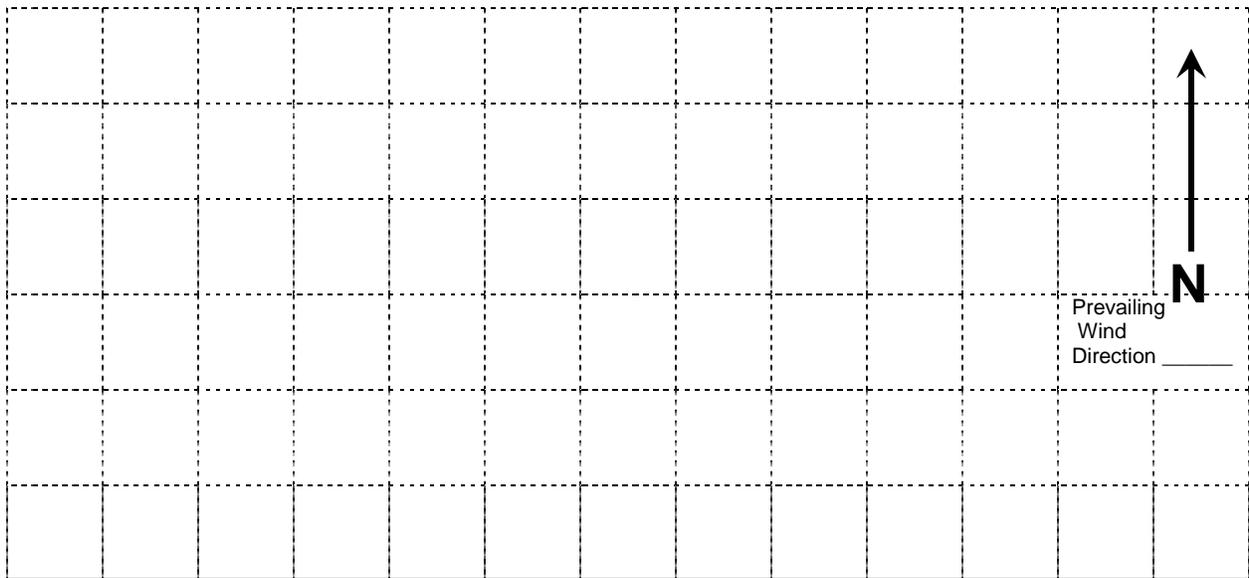
**Seasonal High Tunnel System – Job Sheet**  
**Seasonal High Tunnel System – Layout and Location**

Plan view of seasonal high tunnel system site shown below.

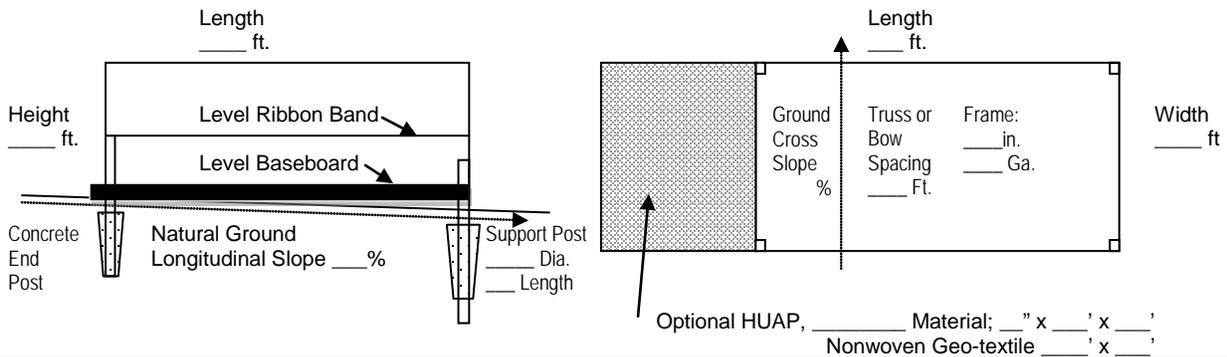
Landowner Name \_\_\_\_\_

Prepared By: \_\_\_\_\_ Date: \_\_\_\_\_

Scale 1"= \_\_\_\_\_ ft. (NA indicates sketch not to scale) or \_\_\_\_\_ see attached sheet.



**Call MUWV (800-245-4848) to locate and mark all utilities within the building area.**



Additional Specifications and Notes:
Roof Runoff-

**Seasonal High Tunnel System – Job Sheet**

Producer \_\_\_\_\_ Location \_\_\_\_\_

Field Office \_\_\_\_\_ Conservation Contract \_\_\_\_\_

Crop(s) \_\_\_\_\_ Expected Months of Use \_\_\_\_\_

Water Source \_\_\_\_\_; GPM \_\_\_\_\_, Distance to SHTS \_\_\_\_\_ (ft), Irrigation Method \_\_\_\_\_

**Materials List**

- High Tunnel Structure, size(s) \_\_\_\_\_ width X \_\_\_\_\_ length X \_\_\_\_\_ height
- Type \_\_\_\_\_ (Gothic, hoop, etc.) \_\_\_\_\_ Manufacturer
- Wind Brace Kit \_\_\_\_\_, Orientation \_\_\_\_\_ Slope (longitudinally) \_\_\_\_\_
- Rafter or Bow Spacing \_\_\_\_\_ (ft.); Gal. Steel Tubing Bows or Trusses \_\_\_\_\_ Dia., \_\_\_\_\_ Gage
- Roof Runoff System:
- Gutter \_\_\_\_\_ type, \_\_\_\_\_ length(ft), \_\_\_\_\_ downspout dia. (in) and number
  - Runoff Protection Area; \_\_\_\_\_ wide (ft) x \_\_\_\_\_ length (ft) x \_\_\_\_\_ thickness (in)  
\_\_\_\_\_ protective material/veg.; \_\_\_\_\_ % slope; \_\_\_\_\_: 1 side slope; \_\_\_\_\_ bottom width (ft)
- Underground Outlet \_\_\_\_\_ dia., \_\_\_\_\_ ft., \_\_\_\_\_ x \_\_\_\_\_ gravel w/ \_\_\_\_\_ SF geotextile

**Supporting Practices Planned:**

- Cover Crop (340)
- Critical Area Planting (342) -job sheet attached
- Diversion (362)- plan attached
- Grassed Waterway (412)- plan attached
- Heavy Use Area Protection (561)
- Irrigation Pipeline (430 DD/EE)
- Irrigation System, Microirrigation (441)
- Irrigation Water Management (449)
- Nutrient Management (590)
- Pest Management (595)
- Pumping Plant (533)
- Roof Runoff System (558) –plan attached
- Subsurface Drain (606)- plan attached
- Underground Outlets (620)- plan attached
- Water Well (642)
- Windbreak/Shelterbelt Establishment (380)
- Surface Ditch-Field Drain (607) –plan attached
- Water Catchment Basin (636); Other: \_\_\_\_\_

### Seasonal High Tunnel System Construction

- Call 1-800 Miss Utility (800-245-4848) and have all above and underground utilities marked prior to construction.
  - Check and adhere to local building codes, ordinances and laws prior to construction.
  - Locate away from structures that may cause snow drift, block ventilation or sunlight and from overhead branches or other obstacles.
  - Prepare site according to manufacturer’s instructions.
  - Lay out building location according to site plan, pay special attention to slope, surface runoff, grading (away from structure), orientation and windbreaks (as appropriate).
  - Assemble high tunnel structure according to manufacturer’s instructions.
- Install supporting practices as required, according to construction plans provided

#### **SUMMARY OF MINIMAL STRUCTURAL CRITERIA FOR A SEASONAL HIGH TUNNEL SYSTEM**

- Galvanized steel frame
- Provide a minimum of 6 mil Clear Greenhouse Grade - 4 year warranty polyethylene film.
- Install wind bracing (supplied by manufacturer) and included for all tunnels in WV.
- Arch rafter, rib or bow spacing a minimum of 4.0'
- Maximum natural ground slope (4% parallel to length, 3% parallel to width)
- Length to width ratio 2:1 (minimum), 4:1 (maximum)
- Crop grown on natural soil or raised beds.
- Crops should be planned for microirrigation to maintain healthy plants.
- Sides should be designed to roll up and ends opened for maximum ventilation during the summer.
- Recommend ventilation be installed on both ends of structure.
- Assemble high tunnel structure according to manufacturer’s instructions.
- Provide roof runoff system with a stable outlet, or collect water for irrigation supplementation

General Size	Small	Medium	Large	Large
Width	12'-14'	15'-20'	20'- 26'	28'-34'
Length	Varies	Varies	Varies	Varies
Extend Growing Season	1-2 months	3-4 months	3-4 months	3-4 months
Minimum number of purlins	2	3	5	5 purlins for a maximum 28' width or 3 purlins w/ truss support
Galvanized Pipe Diameter and Gage	17 gage tubular steel, 1.315" Dia. frame	14gage tubular steel, 1.66" Dia. frame	14 gage tubular steel, 1.66" Dia. frame	13 gage tubular steel, 1.90" Dia. frame
Ground Post Depth* (Min.)	2.0'	2.0'	3.0'	3.0'

\* Install support post a minimum of six" below the frost line and a minimum of 2.0' on small or medium SHTS, and 3.0' deep on large structures. Medium to large structures should include concrete around corner post and every other post or according to manufacture recommendations.

**Seasonal High Tunnel System – Job Sheet**

**Operation and Maintenance**

- Periodically inspect structure and cover for damage. Reinstall and/or repair promptly.
- Follow manufacturer’s instructions for operation and maintenance of the high tunnel structure.
- Avoid damage to structure from equipment operated in and around the seasonal high tunnel.
- Inspect runoff control measures after every significant rainfall event. Repair promptly.
- Remove and store high tunnel cover at the end of each growing season to prevent damage from snow or wind loads as needed. Replace cover prior to use in the spring, as needed.
- Verify Soil PH within the SHTS throughout the year adjust as needed.
- Check Soil Salinity for salts buildup- which could impact crop production.
- Rest soil every 3 to 5 years and plant cover crops to increase soil fertility, remove excess nutrients.
- Aerate areas that may become compacted to maintain water infiltration within the structure.
- Do not use animal manures as compost where plant material may come in contact with the ground and it is for human consumption (unless treated and approved for application). Do not incorporate decomposed plant material unless properly composted (verify weed seeds, fungus, bacteria, etc. is destroyed by checking composting temperatures of 140 deg. F. to 170 deg. F for a minimum of 7 to 21 days).

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**Seasonal High Tunnel System – Construction Checkout**

Seasonal High Tunnel Structure – as-built measurements	
Length (ft)	Height in Center (ft)
Width (ft)	Structure Manufacturer:
Orientation:	Water Source:

**Supporting Practices Installed**

<ul style="list-style-type: none"> <li><input type="checkbox"/> Cover Crop (340)</li> <li><input type="checkbox"/> Critical Area Planting (342) -job sheet</li> <li><input type="checkbox"/> Diversion (362)- plan attached</li> <li><input type="checkbox"/> Grassed Waterway (412)- plan attached</li> <li><input type="checkbox"/> Heavy Use Area Protection (561)</li> <li><input type="checkbox"/> Irrigation Pipeline (430 DD/EE)</li> <li><input type="checkbox"/> Irrigation System, Microirrigation (441)</li> <li><input type="checkbox"/> Irrigation Water Management (449)</li> <li><input type="checkbox"/> Nutrient Management (590)</li> <li><input type="checkbox"/> Pest Management (595)</li> <li><input type="checkbox"/> Pumping Plant (533)</li> <li><input type="checkbox"/> Roof Runoff System (558) –plan attached</li> <li><input type="checkbox"/> Subsurface Drain (606)- plan attached</li> <li><input type="checkbox"/> Underground Outlets (620)- plan attached</li> <li><input type="checkbox"/> Water Well (642)</li> <li><input type="checkbox"/> Windbreak/Shelterbelt Establishment (380)</li> </ul>	<ul style="list-style-type: none"> <li><input type="checkbox"/> Surface Ditch-Field Drain (607) –plan attached</li> <li><input type="checkbox"/> Water Catchment Basin (636);</li> <li><input type="checkbox"/> Other: __</li> <li><input type="checkbox"/></li> </ul>
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**CHECK OUT:**

Amount Completed: \_\_\_\_\_ square feet.                      Mark As-Built location on plan map.

Remarks \_\_\_\_\_

This practice meets NRCS standards and specifications       Yes                       No

Check out by: \_\_\_\_\_                      Date: \_\_\_\_\_

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**Seasonal High Tunnel System – First Year Annual Report** **page 1 of 2**

**Report Due On or Before September 1<sup>st</sup>, 20\_\_\_\_\_**

Producer \_\_\_\_\_ County \_\_\_\_\_  
 Field Office \_\_\_\_\_ Conservation Contract \_\_\_\_\_  
 Report Date \_\_\_\_\_ Copy to Program Manager (SO) \_\_\_\_\_

Resource Concern: \_\_\_ Plant Quality, \_\_\_ Water Quality, \_\_\_ Soil Quality, \_\_\_ Energy Savings

Actual cost of Seasonal High Tunnel System \$\_\_\_\_\_ (attach copies of bills)  
 Tunnel is \_\_\_\_\_ ' wide x \_\_\_\_\_ ' long, Manufactured by \_\_\_\_\_.

Sheet and Rill (Tons/acre): \_\_\_\_\_ Before \_\_\_\_\_ After

Additional Drainage Features are \_\_\_\_\_ and effectiveness (none, low, medium, high).

Growing Season Extension: \_\_\_\_\_ months before \_\_\_\_\_ months after installation.

Annual maintenance requirements: (add more sheets if necessary)

Activity or Item (list)	Cost
	\$

Cropping history before installation of Seasonal High Tunnel: (add more sheets if necessary)

Crop (type)	Crop Year	Yield	Nutrients (Fertilizer)			Pesticide(s)		
			Type	Rate	Timing	Type	Rate	Timing

First year's crop in Seasonal High Tunnel:

Crop (type)	Crop Year	Yield	Nutrients (Fertilizer)			Pesticide(s)		
			Type	Rate	Timing	Type	Rate	Timing

**Seasonal High Tunnel System – First Year Annual Report**

Benefits for

- plant quality: \_\_\_\_\_
- soil quality: \_\_\_\_\_
- water quality: \_\_\_\_\_
- energy savings: \_\_\_\_\_
- Other: \_\_\_\_\_
- Producer's recommendations and observations:  
\_\_\_\_\_

**Seasonal High Tunnel System – Year 2 and 3 Subsequent Report page 2 of 2**

Producer \_\_\_\_\_ Location \_\_\_\_\_  
 Field Office \_\_\_\_\_ Conservation Contract \_\_\_\_\_  
 Report Date \_\_\_\_\_ Copy sent to Program Manager (SO) \_\_\_\_\_

**Report Due On Or Before** \_\_\_\_/\_\_\_\_/\_\_\_\_

- This year's maintenance requirements : (add more sheets if necessary)

Activity or Item (list)	Cost
	\$

- This year's crop in Seasonal High Tunnel:

Crop (type)	Crop Year	Yield	Nutrients (Fertilizer)			Pesticide(s)		
			Type	Rate	Timing	Type	Rate	Timing

- This year's growing season:

Crop (type)	Crop Year	Season Dates	Length of Growing Season (Days)

- Benefits for plant quality: \_\_\_\_\_
- Benefits for soil quality: \_\_\_\_\_
- Benefits for water quality: \_\_\_\_\_
- Increase in Production: \_\_\_\_\_ yield estimate \_\_\_\_\_
- Producer's recommendations and observations:  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_