CHAPTER 8. SOLIDS MANAGEMENT ALTERNATIVES

Solids that are produced as part of the wastewater treatment process must be treated and reused or disposed of in an environmentally and economically acceptable manner. The McMinnville Water Reclamation Facility's (WRF) existing solids management program historically has been very effective. Sludge is thickened with gravity belt thickeners, stabilized using an autothermal thermophilic aerobic digestion (ATAD) process and hauled to agricultural land for use as a soil amendment. The objective of this chapter is to evaluate long-term solids management alternatives that address environmental, regulatory, and growth issues.

EXISTING SYSTEM

Solids at the existing WRF consist of waste activated and chemical sludge that is thickened with gravity belt thickeners and stabilized in the three ATAD units to produce Class A biosolids. Normally, all solids are initially fed into ATAD Tank 1. Following ATAD Tank 1, the solids are directed to ATAD Tank 2, ATAD Tank 3, or both. Withdrawal is controlled automatically by the operation of four motorized control valves mounted on the outlet piping of ATAD Tank 1. ATAD Tank 2 and ATAD Tank 3 are each equipped with two motorized control valves on the outlet piping. Transfer pumps are utilized to move the solids to the Biosolids Storage Tank or between ATAD tanks.

Biosolids are hauled to local farmers' fields when weather conditions permit application. It should be noted that Department of Environmental Quality's (DEQ) policies on land application are becoming more restrictive with respect to approval of fields for wet season application.

Sludge Production. Future sludge quantities will primarily be a function of population growth and increased loads from commercial and industrial system users. Table 8-1 presents a summary of the projected sludge quantities.

Table 8-1. Solids Loading Projections

Parameter	Existing	Buildout
Average WAS and Chemical Sludge, ppd(a)	6,700	12,700
Average WAS and Chemical Sludge, gpd(b)	98,400	186,000
Maximum Month WAS and Chemical Sludge, ppd	11,200	21,700
Maximum Month WAS and Chemical Sludge, gpd	150,200	283,900
Annual Average Thickened Sludge, gpd(c)	16,100	30,700
Maximum Month Thickened Sludge, gpd	26,300	50,000
Average Annual Digested Sludge, ppd	4,300	8,100
Average Annual Digested Sludge, gpd	14,700	27,700
Maximum Month Digested Sludge, ppd	7,600	14,400

(a) Pounds per day
(b) Gallons per day
(c) 5% solids

Table 8-2 summarizes the design capacity of solids treatment unit processes.

Table 8-2. Existing Solids Processing Capacity

Unit Process	Design Parameter	Design Criteria	Capacity
Gravity Belt Thickener	gpm/meter of belt width	200(a)	288,000 gpd(c)
ATAD Digestion	hydraulic retention time	8 days(b)	25,400 gpd
ATAD Digestion	VSS volumetric loading	230 lb/kcf(d)	6,200 ppd
Biosolids Storage	hydraulic retention time	210 days(b)	13,500 gpd

(a) Based on current operation
(b) From design drawings (CH2M Hill, 1993)
(c) Based on one-shift per day, 7 days/week operation. Actual daily operation time is assumed to be 6 hours.
(d) From Wastewater Engineering, 4th Edition (Metcalf & Eddy, 2003)

SOLIDS MANAGEMENT STRATEGY EVALUATION CRITERIA

This section presents the management strategy evaluation criteria.

Regulatory Criteria

Biosolids management is closely regulated by Federal regulations. These laws have been designed to protect public health and the environment from adverse effects that may be reasonably anticipated when biosolids are applied to land. The governing biosolids regulations were developed by the U.S. Environmental Protection Agency and are contained in Title 40 of the Code of Federal Regulations, Part 503 (commonly referred to as 40 CFR Part 503, or “the Part 503 rules”). These rules have been adopted by the Oregon Department of Environmental Quality (DEQ) and therefore establish the requirements for the final use or disposal of biosolids produced at the WRF.

All biosolids that are applied to land must meet three basic requirements:

- *Pollutant Limits.* Pollutant limits for 10 heavy metals cannot be exceeded. For land application of the biosolids, maximum (“ceiling”) concentration limits cannot be exceeded. If any of the ceiling limits are exceeded, the biosolids cannot be land applied. In addition, the biosolids must meet either pollutant concentration limits, cumulative pollutant loading rate limits or annual pollutant loading rate limits.
- *Pathogen Limits.* Pathogens are disease-causing organisms that are present in sewage sludge. Pathogen requirements must be met along with corresponding access restrictions to the biosolids application site. Biosolids are designated as Class A if the pathogens are below regulatory limits. Class B biosolids have reduced levels of pathogens that do not pose a threat to public health or the environment if applied according to regulations for Class B biosolids.

- *Vector Attraction Limits.* Vectors are organisms such as rodents or insects that can spread disease by carrying and transferring pathogens. Sludge treatment processes must utilize one of the 10 vector attraction reduction (VAR) methods that are required by the Part 503 rules.

Agricultural Practices

In recent years, Yamhill County has become one of Oregon's premier wine grape growing areas. Many grass fields and pasture lands that have historically been considered potential biosolids application sites are being converted to vineyards. Changing agricultural practices may limit the available local acreage for beneficial reuse, require a higher quality product and/or increase haul distance.

Public Acceptance

Biosolids provide value by returning nutrients to the soil. They are applied to agricultural land through an agreement between the City and the landowner. The ability to find and maintain suitable application sites is dependent on public acceptance of the product. To that end, the City has maintained a consistent high quality product and application methods have been acceptable to land owners. The preferred management strategy should include continued attention to high product quality, good application practices and aesthetics.

Odor

Reducing odor on the WRF site provides a comfortable work environment for operation and maintenance staff. Odor associated with the product at the land application site creates a negative public reaction at and near the site. The recommended strategy should minimize and control odors.

Energy Cost

Management strategies with lower energy requirements are preferred. Strategies that provide opportunities for energy recovery from the stabilization process would be considered more favorable.

Fuel Cost

Fuel costs, already at unprecedented levels, may continue to rise. The preferred management strategy should minimize the volume of material to be hauled. Haul distance would be minimized through local reuse or disposal.

Ease of Operation and Maintenance

Operation and maintenance of a wastewater treatment facility covers a broad spectrum of tasks required to provide reliable performance. The following factors were considered:

- *Operability.* The recommended strategy should have operational requirements typical of conventional treatment facilities.
- *Flexibility.* The recommended strategy should be adaptable to allow a variety of cost-effective disposal options.

- *Reliability*. The preferred strategies should provide quality, performance, the ability to take units out of service, and bypassing capability.
- *Maintainability*. The recommended strategy should consider access and safety.

Volatile Solids Reduction

The preferred strategy must reliably comply with volatile solids reduction requirements.

Increased Sustainability

Management strategies, which minimize impact on the environment by beneficially reusing resources to the greatest extent possible, are favored.

Flexibility in End Use

The ability to land apply solids may change suddenly due to poor weather conditions, transportation issues, changes in land ownership or contractual issues with users. Management strategies, which provide the City with flexibility to change disposal or reuse practices on short notice, are favored.

Implementation

The preferred management strategy should be easily integrated into the WRF's existing facility. Other implementation considerations are:

- Reasonable cash flow to build the necessary capital improvements
- Land availability
- Ability to maintain facilities in operation during construction.

BIOSOLIDS PRODUCT

A biosolids product is characterized by its quality (meeting Class A or B criteria) which is the result of the solids processing technology used to produce it, and by its form. Both of these characteristics determine where and how the biosolids can be beneficially reused or disposed.

Level of Treatment

Solids management strategies are based on a level of treatment to produce Class A biosolids. The WRF currently produces Class A biosolids that allows the most flexibility in options for beneficial reuse of the biosolids. The City intends to continue to produce a Class A product. Therefore, solids management strategies will only include those that will produce Class A biosolids.

Form of Biosolids Product

Class A biosolids can be produced as a liquid, dewatered cake or dried product. The WRF currently produces a liquid product. Generally speaking, the drier the product, the more flexibility is allowed in its use.

- *Liquid (solids concentration of 1-6%).* Liquid biosolids are taken directly from a digester or similar stabilization process. The biosolids are land applied using injection or spraying. Biosolids in liquid form are not accepted at landfills.
- *Dewatered Cake (solids concentration of 16 – 25%).* Biosolids are dewatered by one of several processes to a cake with a consistency of wet clay, with plastic flow characteristics. Dewatered biosolids can be land filled or land applied with a manure spreader.
- *Lime-stabilized Biosolids (solids concentration of approximately 50%).* Biosolids are dewatered and pasteurized with lime to produce a granular material that can be land applied or land filled.
- *Dried Biosolids (solids concentration of 75 - 90% solids).* Biosolids are thermally dried to a powdery consistency. Dried biosolids can be land filled, composted, given or sold directly to the public, or land applied.
- *Compost.* Dewatered biosolids are composted with a bulking agent such as sawdust or yard debris. Compost can be land applied or given or sold directly to consumers.

Table 8-3 summarizes potential end uses for the various forms of Class A biosolids.

Table 8-3. Potential End Uses for Forms of Class A Biosolids

Biosolids Product Form	Land Application	Landfill	Direct to Consumer
Liquid	x		
Dewatered	x	x	
Lime-stabilized	x	x	
Dried	x	x	x*
Compost	x	x	x

*****Solids content of more than 90%

DEVELOPMENT OF SOLIDS MANAGEMENT STRATEGIES

Based on the criteria listed above, several management strategies were identified and reviewed in an October 31, 2007 workshop. This section presents a summary of six strategies for solids management (SM) alternatives. All management alternatives include continued gravity belt thickening of WAS and chemical sludge. The management alternatives can be classified into two approaches:

1. Continue with ATAD treatment of all sludge.
    1A. Expand ATAD Facilities
    1B. Expand ATAD Facilities and Dewater

2. Continue with ATAD treatment of sludge to the capacity of the existing process. Construct a parallel process for treatment of sludge quantities that exceeds the capacity of the ATAD process.
    2A. Add Dewatering and Thermal Drying
    2B. Add Dewatering and Lime Stabilization
    2C. Add Dewatering and Composting

Strategy SM1A: Expand ATAD Facilities

This alternative involves continuing to treat solids with the existing ATAD process and expanding the ATAD process and liquid storage facilities to process increased sludge quantities. A new 1 million gallon (MG) liquid sludge storage tank would be constructed in the first phase of this alternative. Three additional ATAD tanks and a second mixing tank would be constructed in the future to provide the required storage volume for buildout digested biosolids production. They could be added as they are needed or all at one time. Basic design data for this alternative is shown in Table 8-4 and a schematic of this alternative is shown in Figure 8-1.

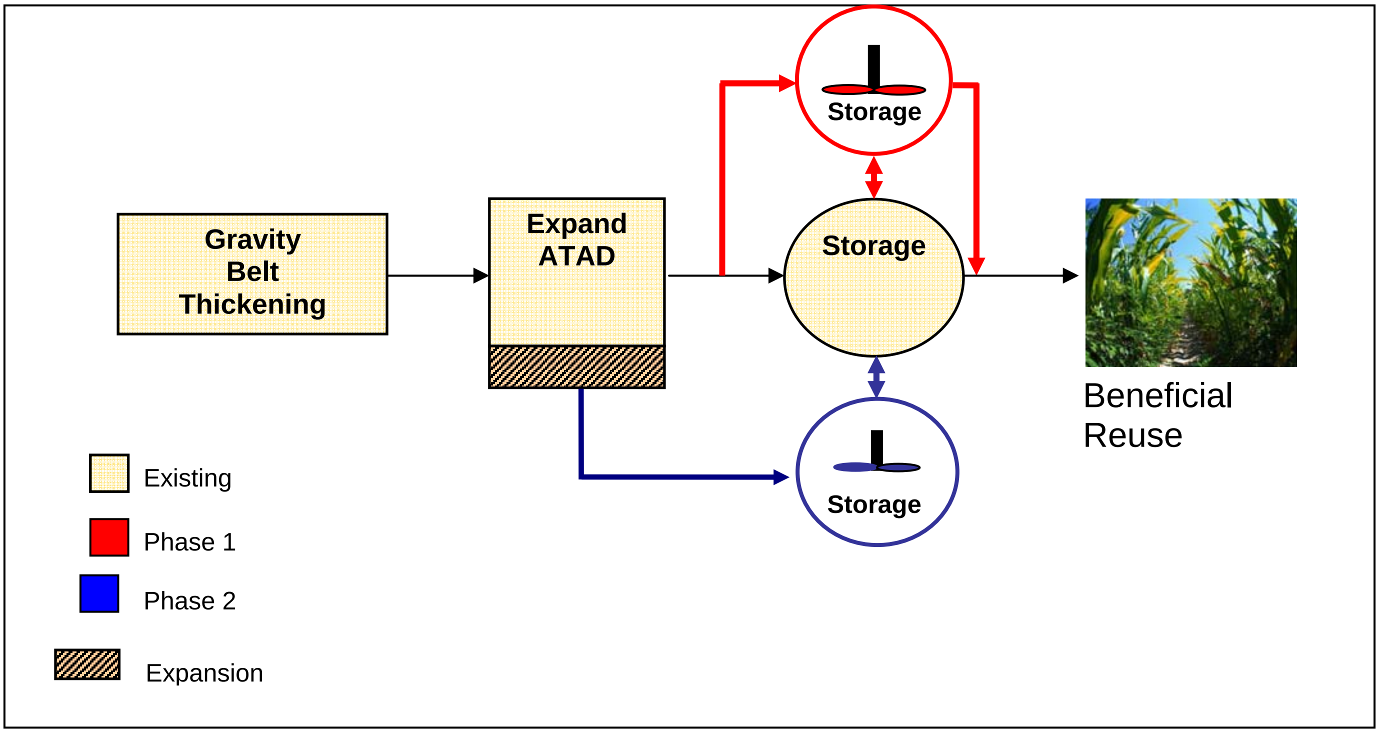
Table 8-4. Strategy SM1A. Expand ATAD – Design Data

Description	Existing*	Phase 1	Phase 2
ATAD Digestion			
Number of tanks	3	4	6
Capacity, each, gallons	67,630	67,630	67,630
Hydraulic Detention Time, days**			
Average Day	13	13	13
Maximum Month	8	8	8
Liquid Biosolids Storage			
Number of Tanks	1	2	2
Volume, each, million gallons	2.8	1@ 1.0	1@1.0
		1@2.8	1@2.0
			1@2.8
Capacity, days at average day biosolids production	190	210	210
Mixing Energy, hp, each			
2.8 MG Tank	None	None	None
1.0 MG Tank		60	60
2.0 MG Tank			100
Biosolids Product, Class A	Liquid	Liquid	Liquid

* Data is based on current solids production.

** Detention times shown assume new tanks are constructed as needed to meet design criteria.

Figure 8-1. Strategy SM1A: Expand ATAD Facilities



Strategy SM1B: Expand ATAD Facilities and Dewater

Like Alternative SM1A, this alternative includes expanding the ATAD process to accommodate buildout thickened sludge quantities by adding three ATAD tanks. The tanks could be constructed as needed or all at one time. A new one million gallon storage tank would be constructed in Phase 1 of this alternative. However, instead of constructing a third liquid storage tank in the future, a dewatering process would be provided to decrease the volume of stabilized biosolids to be hauled and land applied. The dewatering process would be sized to process average-day solids operating approximately one shift seven days per week year round. Additional storage would be provided for the dewatered biosolids. Basic design data for this alternative is shown in Table 8-5 and a schematic of this alternative is shown in Figure 8-2.

Table 8-5. Strategy SM1B. Expand ATAD and Dewater – Design Data

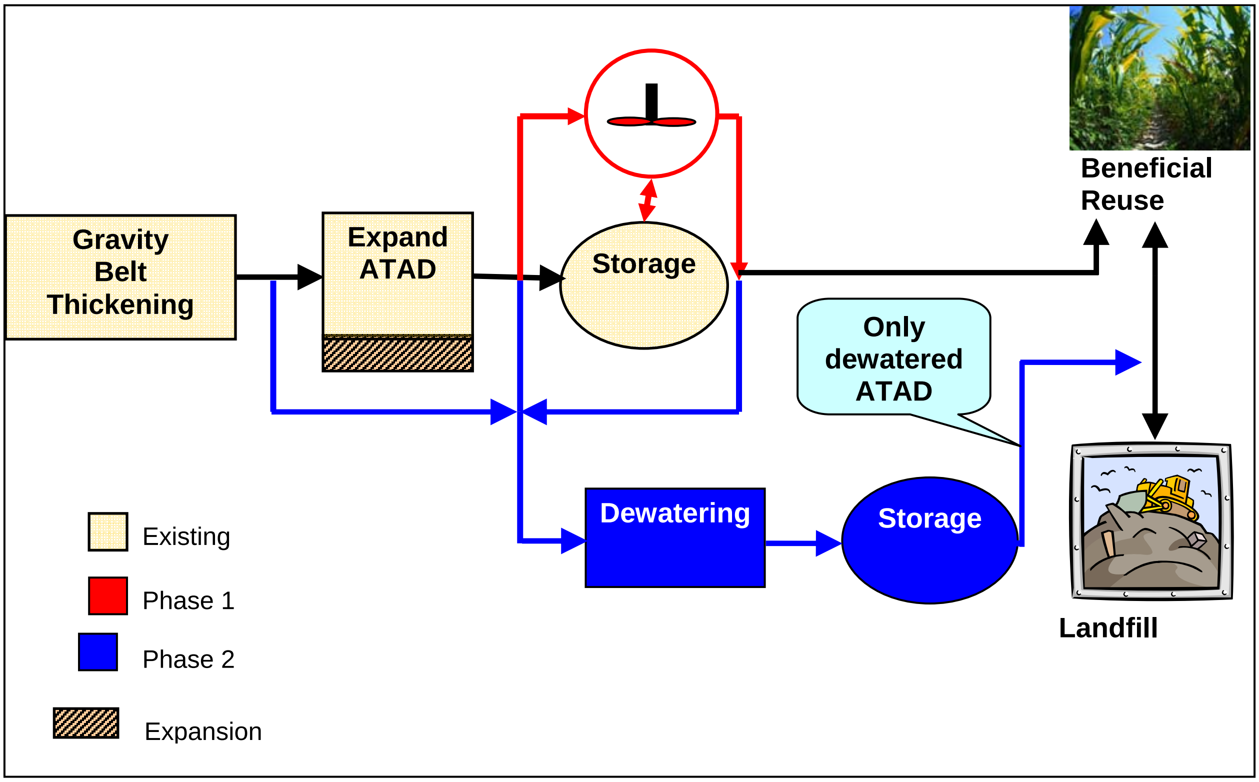
Description	Existing*	Phase 1	Phase 2
ATAD Digestion			
Number of tanks	3	4	6
Capacity, each, gallons	67,630	67,630	67,630
Hydraulic Detention Time, days**			
Average Day	13	13	13
Maximum Month	8	8	8
Liquid Biosolids Storage			
Number of Tanks	1	2	2
Volume, each, million gallons	2.8	1@1.0	1@1.0
		1@2.8	1@2.8
Capacity, days at average day biosolids production	190	210	140
Mixing Energy, hp, each			
2.8 MG Tank	None	None	None
1.0 MG Tank		60	60
Dewatering			
Type	—		TBD
Number of Units	—		1
Loading	—		
GPM			33
Pounds per hour (PPH)			800
Dewatered Biosolids Storage days	—	—	70
Biosolids Product, Class A	Liquid	Liquid	Liquid, Dewatered

TBD – to be determined

*Data is based on current solids production.

**Detention times shown assume new tanks are constructed as needed to meet design criteria.

Figure 8-2. Strategy SM1B: Expand ATAD Facilities and Dewater



Strategy SM2A: Add Dewater and Thermal Drying

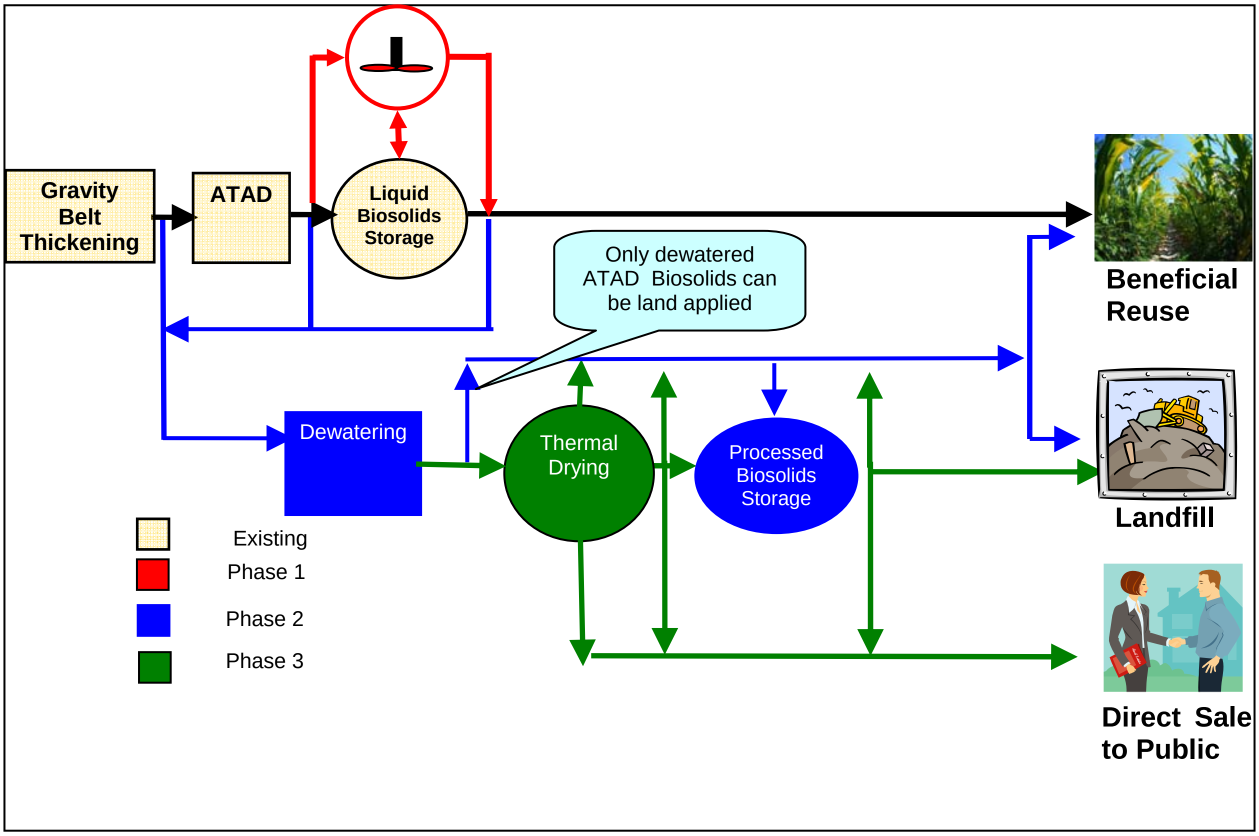
In this alternative, the existing ATAD system is used to its full capacity. One million gallons of liquid storage would be added in the first phase of this alternative. Dewatering of thickened and stabilized biosolids and dewatered biosolids storage would be added in the second phase. The third phase of the alternative would include thermal drying for stabilizing sludge in excess of the ATAD capacity. Thermal drying uses natural gas to heat the sludge resulting in a powdery product with a solids content exceeding 90%. The dewatering and thermal drying equipment would be sized to process average day solids production while operating approximately one shift seven days per week year round. Maximum month conditions would be met by increasing operating hours. The energy cost for this alternative could be offset by converting the 1 MG storage tank to an anaerobic digester and capturing methane to fuel the dryer. In this alternative, for the period of time between which ATAD capacity is reached and thermal drying is constructed, unstabilized sludge would need to be dewatered and land filled. Basic design data for this alternative is shown in Table 8-6 and a schematic of this alternative is shown in Figure 8-3.

Table 8-6. Strategy SM2A: Add Dewatering and Thermal Drying – Design Data

Description	Existing*	Phase 1	Phase 2	Phase 3
ATAD Digestion				
Number of tanks	3	3	3	3
Capacity, each, gallons	67,630	67,630	67,630	67,630
Hydraulic Detention Time, days				
Average Day	13	9	13	13
Maximum Month	8	5	8	8
Liquid Biosolids Storage				
Number of Tanks	1	2	2	2
Volume, each, million gallons	1@2.8	1@1.0	1@1.0	1@1.0
		1@2.8	1@2.8	1@2.8
Capacity, days at average day biosolids production	190	210	160	140
Mixing, hp				
2.8 MG Tank	None	None	None	None
1.0 MG Tank		60	60	60
Dewatering				
Type	-			TBD
Number of Units	-			1
Loading	-			
GPM			32	33
PPH			770	800
Thermal Drying				
Number of Units	-			1
Loading , wet tons/day	-			32
Biosolids Storage, days	-	-	30 (dewatered)	170 (dried)
Biosolids Product, Class A	Liquid	Liquid	Liquid, Dewatered	Liquid, Dewatered, Dried

*Data is based on current solids production.

Figure 8-3. Strategy SM2A: Add Dewater and Thermal Drying



Strategy SM2B. Add Dewatering and Lime Stabilization

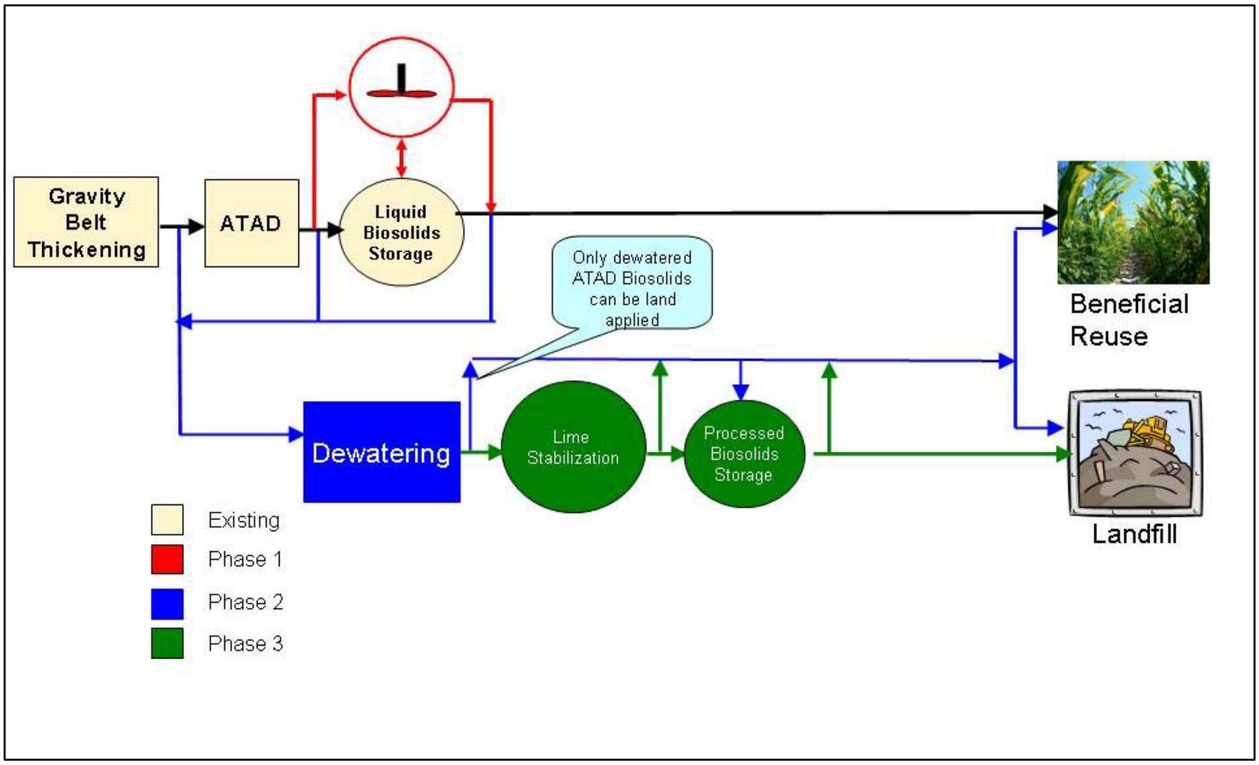
Similar to Strategy SM2A, in this alternative, the existing ATAD system is used to its full capacity. One million gallons of liquid storage would be added in the first phase of this alternative. Dewatering of thickened and stabilized biosolids and dewatered biosolids storage would be added in the second phase. The third phase of the alternative would include lime stabilization for sludge in excess of the ATAD capacity. Lime storage would be provided to be consistent with delivery quantities. The dewatering and lime stabilization equipment would be sized to process average day solids production operating approximately one shift seven days per week year round. Maximum month conditions would be met by increasing operating hours. In this alternative, for the period of time between which ATAD capacity is reached and lime stabilization is constructed, unstabilized sludge would need to be dewatered and land filled. Basic design data for this alternative is shown in Table 8-7 and a schematic of this alternative is shown in Figure 8-4.

Table 8-7. Strategy SM2B: Add Dewatering and Lime Stabilization – Design Data

Description	Existing*	Phase 1	Phase 2	Phase 3
ATAD Digestion				
Number of tanks	3	3	3	3
Capacity, each, gallons	67,630	67,630	67,630	67,630
Hydraulic Detention Time, days				
Average Day	13	9	13	13
Maximum Month	8	5	8	8
Liquid Biosolids Storage				
Number of Tanks	1	2	2	2
Volume, each, million gallons	1@2.8	1@1.0	1@1.0	1@1.0
		1@2.8	1@2.8	1@2.8
Capacity, days at average day biosolids production	190	210	160	140
Mixing, hp				
2.8 MG Tank	None	None	None	None
1.0 MG Tank		60	60	60
Dewatering				
Type	—			TBD
Number of Units	—			1
Loading	—			
GPM			32	33
PPH			770	800
Lime Stabilization				
Number of Units	—			1
Loading , PPH	—			800
Lime Storage, tons				50
Biosolids Storage, days	—	—	30 (dewatered)	70 (lime stabilized)
Biosolids Product, Class A	Liquid	Liquid	Liquid, Dewatered	Liquid, Dewatered, Lime Stabilized

*****Data is based on current solids production.

Figure 8-4. Strategy SM2B: Add Dewatering and Lime Stabilization



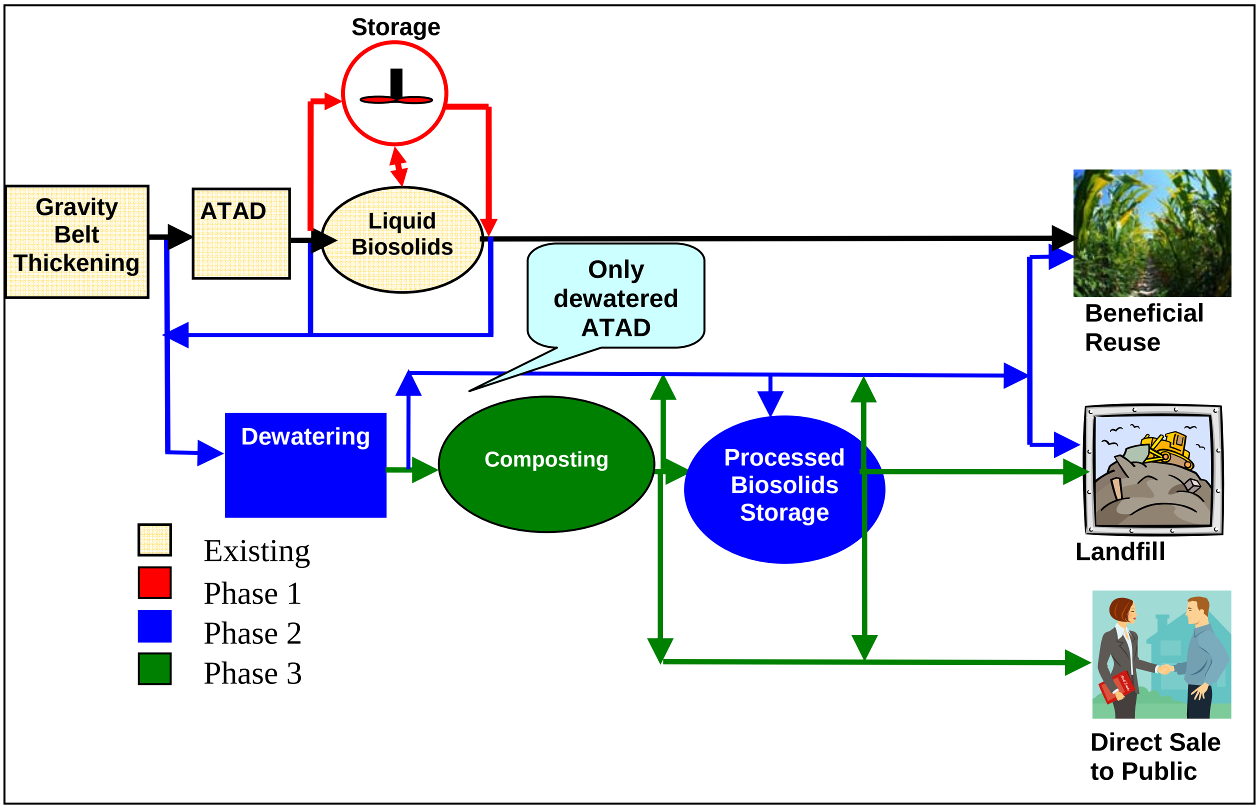
Strategy SM2C. Add Dewatering and Composting

Similar to Strategies SM2A and SM2B, in this alternative, the existing ATAD system is used to its full capacity. One million gallons of liquid storage would be added in the first phase of this alternative. Dewatering of thickened and stabilized biosolids and dewatered biosolids storage would be added in the second phase. The third phase of the alternative would include a composting operation for stabilization of sludge in excess of the ATAD capacity. The dewatering equipment would be sized to process average day solids production operating one shift seven days per week year round. Maximum month conditions would be met by increasing operating hours. The composting portion of this alternative was developed based on an aerated static pile process. Yard debris would be used as a bulking agent and combined with the biosolids at slightly more than a 1-to-1 ratio. Facilities associated with this strategy would include a paved work area, a covered area for processing, an aeration system, equipment for moving the material, equipment for grinding and screening, odor control, biosolids storage and stormwater control facilities. In this alternative, for the period of time between which ATAD capacity is reached and composting facilities are constructed, unstabilized sludge would need to be dewatered and land filled. Basic design data for this alternative is shown in Table 8-8 and a schematic of this alternative is shown in Figure 8-5.

Table 8-8. Strategy SM2C: Add Dewatering and Composting – Design Data

Description	Existing*	Phase 1	Phase 2	Phase 3
ATAD Digestion				
Number of tanks	3	3	3	3
Capacity, each, gallons	67,630	67,630	67,630	67,630
Hydraulic Detention Time, days				
Average Day	13	9	13	13
Maximum Month	8	5	8	8
Liquid Biosolids Storage				
Number of Tanks	1	2	2	2
Volume, each, million gallons	1@2.8	1@1.0	1@1.0	1@1.0
		1@2.8	1@2.8	1@2.8
Capacity, days at average day biosolids production	190	210	160	140
Mixing, hp				
2.8 MG Tank	None	None	None	None
1.0 MG Tank		60	60	60
Dewatering				
Type	—			TBD
Number of Units	—			1
Loading	—			
GPM			32	33
PPH			770	800
Composting Capacity, wet tons/day				32
Biosolids Storage, days	—	—	30 (dewatered)	70 (composted)
Biosolids Product, Class A	Liquid	Liquid	Liquid, Dewatered	Liquid, Dewatered, Composted

Figure 8-5. Strategy SM2C. Add Dewatering and Composting



MANAGEMENT STRATEGY SCREENING

This section presents a screening of alternative strategies based on their ability to meet the criteria previously described. This initial screening was performed with the WRF personnel during the work session on October 31, 2007. A summary of the findings is shown in Table 8-9.

Table 8-9. Solids Management Strategies Screening Results

Response	Regulatory Criteria	Changing Agricultural Practices	Public Acceptance	Odor	Energy Cost	Fuel Cost	Ease of Operation and Maintenance	VSS Reduction	Sustainability Requirements	Flexibility in End Use	Implementation
SM1A: Expand ATAD	0	-	-	-	+	-	0	0	0	-	0
SM1B: Expand ATAD and Dewater	0	+	0	-	+	0	-	0	0	0	0
SM2A: Add Dewatering and Thermal Dry	+	+	+	-	-	+	-	+	-	+	+
SM2B: Add Dewatering and Lime Stabilization	+	+	+	-	0	+	-	+	-	+	+
SM2C: Add Dewatering and Composting	-	+	+	-	+	-	-	-	+	+	+

- Alternative would be inferior in meeting this criteria

0 Alternative would be neutral in meeting this criteria

+ Alternative would be superior in meeting this criteria

The screening process is summarized as follows:

Strategy SM1A. Expand ATAD extends the existing biosolids stabilization process. This alternative continues with a process which had historically problematic performance but which has improved with the recent installation of new aeration equipment. Continuing with the ATAD process limits the City’s flexibility with regard to biosolids disposal and reuse due to the liquid product form and the odor associated with it. The liquid product is desirable during the driest months and is comparatively easy to land apply. However, it is not accepted at landfills and is very expensive to haul any distance. Therefore, this alternative leaves the City with no flexibility in the event that local land application is discontinued. In addition, the odor associated with the product jeopardizes its continued public acceptance.

Strategy SM1B. Expand ATAD and Dewater is similar to Strategy SM1A in that it would retain the ATAD process for biosolids stabilization. Dewatering the biosolids would expand the City’s options for disposal and reuse. Dewatered biosolids are accepted at landfills and would be less expensive to haul longer distances should the City have to look farther away for a landowner willing to accept the product. It should be noted that ATAD biosolids are difficult to dewater and a significant amount of polymer is required to achieve an acceptable dewatered cake concentration. This alternative does not eliminate the odors associated with the ATAD biosolids. In addition to odor continuing to be an issue at the land application site, the dewatering process would require significant odor control.

*Strategy SM2A***.** *Add Dewatering and Thermal Drying* would retain the existing ATAD process and add a parallel thermal reduction process. The relatively odor free dried product would reduce the likelihood of odor complaints where it was land applied and its powdery consistency may be more acceptable to the public. In addition, the dried product gives the City several options for beneficial reuse or disposal. It could be land applied most of the year, sold directly to consumers or used as a bulking agent for compost. If not accepted locally for land application, the product could be hauled to eastern Oregon or land filled relatively economically. The flexibility comes at a price; drying sludge is the most energy intensive alternative. For this reason, it may be advantageous to consider converting the 1 MG storage tank to an anaerobic digester to recover methane to supplement natural gas as fuel for the dryer.

Strategy SM2B. Add Dewatering and Lime Stabilization also retains the existing ATAD process and adds a parallel stabilization process, lime pasteurization. After dewatering, the solids would be stabilized with lime through an exothermic chemical reaction. This process would produce a 50% dry solids and lime cake that could be land applied as a soil amendment possibly year round and would be expected to be sought after by area landowners. Since this strategy produces a high solids content cake, it too could more affordably be land filled or hauled to more remote land application site if the local land application program were to be interrupted. This alternative has the disadvantage of requiring a relatively large amount of lime that must be hauled and land applied with the biosolids. In addition, processes that use lime can be dusty and unpleasant to operate. Odors can be a concern since ammonia is released as a product of the reaction of lime with the sludge.

Strategy SM2C. Like the previous two alternatives, *Add Dewatering and Composting* retains the existing ATAD process and adds a parallel stabilization process. Composting facilitates the decomposition of the biosolids with a bulking agent to provide heat for volatile solids and pathogen reduction. The benefits of this alternative are its very low energy usage and desirable end product. Disadvantages are that it is labor intensive and requires a significant site area. In addition, odor is a significant concern with a composting operation and would require a sizeable odor control system. The product would be marketable as a soil stabilizer and/or amendment. Revenue could partially offset operation costs. However, a market analysis would need to be conducted to confirm and quantify demand for the product.

STRATEGY PRESENT WORTH COST EVALUATION

An economic evaluation of the strategies was performed. The economic evaluation included development of present worth (PW) costs which included estimated capital and operation and maintenance (O&M) costs.

Capital Cost

It was assumed that centrifuges would be used for dewatering in development of the capital cost estimates. Table 8-10 summarizes the estimated capital costs for the solids management strategies.

Table 8-10. Solids Management Strategies Estimated Capital Costs, 2008 $ ($1,000)

Item	SM1A	SM1B	SM2A	SM2B	SM2C
Expand ATAD	6,500	6,500			
1 MG Biosolids Storage Tank with Mixing	2,100	2,100	2,100	2,100	2,100
2 MG Biosolids Storage Tank with Mixing	3,000				
Dewatering		2,800	2,800	2,800	2,800
Thermal Drying			4,600		
Lime Stabilization				3,700	
Composting					3,000
Finished Biosolids Storage		700	300	1,200	1,200
Estimated Base Construction Cost	11,600	12,100	9,800	9,800	9,100
Contractor General Conditions (10%)	1,200	1,200	1,000	1,000	900
Contractor Overhead and Profit (15%)	1,700	1,800	1,500	1,500	1,400
Estimated Total Construction Cost	14,500	15,100	12,300	12,300	11,400
Contingencies (30%)	4,400	4,600	3,700	3,700	3,400
Engineering Legal and Administration (25%)	4,700	5,000	4,000	4,000	3,700
Total Estimated Capital Cost	23,600	24,700	20,000	20,000	18,500

Operation and Maintenance Cost

The following assumptions were made in the development of the operation and maintenance costs.

- Dewatered sludge cake concentration would be 16%.
- Biosolids would be locally land applied with an average haul distance of 8 miles from the WRF to the beneficial reuse site.
- Strategies SM2A, SM2C would produce a biosolids product that could potentially be marketed and produce income for the WRF. However, since the size and potential success of such a program is difficult to predict, no credit was taken for income.

Table 8-11 summarizes the estimated present worth operation and maintenance cost of the solids management strategies.

Table 8-11. Estimated Present Worth O&M Cost, 2008 $ ($1,000)

Item	SM1A	SM1B	SM2A	SM2B	SM2C
Labor	2,600	3,300	4,200	4,400	4,500
Energy	2,400	2,000	3,900	1,700	1,600
Materials	200	200	300	300	800
Chemicals	—	1,500	400	1,200	400
Estimated PW O&M Cost	5,200	7,000	8,800	7,600	7,300

Total Present Worth Cost

Table 8-12 summarizes the estimated present worth costs of the solids management strategies.

Table 8-12. Solids Management Strategies Estimated Present Worth Cost, 2008 $ ($1,000)

Item	SM1A	SM1B	SM2A	SM2B	SM2C
Capital Cost	23,600	24,700	20,000	20,000	18,500
PW O&M Cost	5,200	7,000	8,800	7,600	7,300
Total Estimated PW Cost	28,800	31,700	28,800	27,600	25,800

Based on the present worth cost evaluation, strategies SM1A, SM2A, SM2B and SM2C have the lowest present worth costs; are within the accuracy of the cost estimate; and could therefore be considered relatively equivalent in cost. Strategy SM1A would continue to provide only liquid biosolids while strategies SM2A, SM2B and SM2C provide more than one form of biosolids and therefore flexibility with regard to biosolids disposal or reuse and are therefore recommended.

Non-Economic Evaluation

Table 8-13 summarizes the non-economic evaluation of the solids management strategy alternatives.

Table 8-13. Non-economic Evaluation of Solids Management Strategies.

Evaluation Criteria	Strategy SM1A Expand ATAD	Strategy SM1B Expand ATAD and Dewater	Strategy SM2A Add Dewatering and Thermal Drying	Strategy SM2B Add Dewatering and Lime Stabilization	Strategy SM2C Add Dewatering and Composting
Performance	Volatile solids reduction has been consistent with ATAD over the last year.	Volatile solids reduction has been consistent with ATAD over the last year.	Drying provides effective pathogen reduction.	Lime stabilization provides effective pathogen reduction.	Composting provides pathogen reduction if operated properly.
Expandability	Additional tankage would be required.	Additional tankage would be required for expansion. Dewatering equipment operation could be extended to expand capacity.	Dewatering and drying operating time could be extended to expand capacity.	Dewatering and lime stabilization equipment operation time could be extended to expand capacity.	Dewatering operation time could be extended to expand capacity. Composting area could easily be expanded.
Ease of Operation	ATAD operation is familiar to operation staff.	ATAD operation is familiar to operation staff. Dewatering process would add equipment.	Dewatering and thermal drying would add equipment. Process would be operated one shift per day for most of the year.	Dewatering and lime stabilization would add equipment. Process would operate one shift per day for most of the year. Lime stabilization requires chemical handling and the process is dusty.	Composting is a labor-intensive process and requires significant quantity of a suitable bulking agent. Odorous air volumetric quantities also are greater for this process.
Reliability	Additional tankage provides redundancy.	Additional tankage and ability to dewater provides redundancy.	Parallel process with proven track record provides reliability.	Parallel process with proven track record provides reliability.	Parallel process provides redundancy. Reliable results with composting may require a substantial amount of monitoring and refinement.
Constructability	Construction would require some modification to the existing process.	Construction would require some modification to the existing process.	Construction would not interfere with the existing process.	Construction would not interfere with the existing process.	Construction would not interfere with the existing process.

SOLIDS UNIT PROCESS IMPROVEMENT ALTERNATIVES

Sludge Dewatering

Different mechanical dewatering technologies are available in the industry to reduce the water content of the stabilized biosolids. The following technologies are often evaluated for dewater applications:

- Centrifuges. Centrifuges have a history of successful dewatering operation. The most common type of centrifuge unit is a solid bowl, which operates as a continuous feed unit. This unit removes solids by scroll conveyor and discharges liquid over a weir. The solid bowl, into which is inserted the spiral conveyor are rotated together at high speeds. These two combined units are often called the rotating assembly. Solids are displaced to the bowl periphery by centrifugal forces. Cake solids are a function of sludge characteristics and polymer use. Centrate from this process would be pumped to the secondary process.
- Belt Filter Presses. Belt filter presses are also a dewatering technology with a long track record of successful operation. Water drains from the solids as they are conveyed on a belt over rollers. At the end of the machine, solids are pressed between two belts. Cake solid concentration is a function of sludge characteristics and polymer use. Filtrate from this process would be pumped to the secondary process.
- Rotary Fan Press. Rotary presses are currently manufactured by two companies – Fournier Industries and Prime Solutions Inc. Sludge or biosolids would be conditioned with a dose of polymer to promote flocculation and coagulation of the solids. The solids would then be pumped into the rotary press, which consists of a series of hollow discs that enclose stainless steel screens. As the filtrate passes through the screens, a cake forms inside the screens. The screens are in constant, slow rotation (approximately 0.5-3 revolutions per minute) and act to slowly move the sludge towards the outlet. During this process, water drains through the screens. The outlet port is pressure controlled, acting to squeeze the sludge to remove more water just prior to discharge. Pressate from this process would be pumped to the secondary process.

These technologies are qualitatively compared in Table 8-14. The actual performance of the technologies is largely dependent on the characteristics of the biosolids. Pilot testing may be performed during predesign to determine the expected performance of the dewatering equipment and the actual operation cost.

Table 8-14. Comparison of Dewatering Technologies

Evaluation Criteria	Centrifuges	Belt Filter Press	Rotary Press
O&M Considerations.	More skilled labor required for operation. Noise attenuation required.	Requires intermittent adjustment to meet performance. Safety guards required around moving parts.	Somewhat unknown. Relatively uncomplicated operation.
Reliability	Established operational experience. Potential for dryer cake with high solids centrifuge but with higher polymer dosages.	Established operational experience. Generally produces wetter cake than high solids centrifuge.	Relatively new to the industry. May not be suitable for ATAD sludge.
Odor Potential	Enclosed process.	Open process is usually equipped with an odor hood.	Enclosed process.
Flexibility	Require longer run times to process higher sludge loading.	Require longer run times to process higher sludge loading.	Can ultimately add to the equipment to accommodate higher loading.
Complexity	Relatively complex with sophisticated controls	Relatively simple process.	Relatively simple process.
Energy Use	High-energy use.	Low energy use.	Low energy use.

Biosolids Disposal and Reuse

The end use of biosolids produced at the WRF will depend on the characteristics of the product. Biosolids quantity will increase proportionally to the loads to the plant as shown previously in Table 8-1. It is most economical to locally land apply solids. Other alternatives include land filling or hauling to Eastern Oregon for land application. Liquid biosolids are not accepted by landfills. In addition, the dryer the product, the lower the hauling costs, since hauling cost is based on weight. Table 8-15 summarizes the unit cost of hauling and disposing of or land applying the various forms of biosolids to alternative disposal or beneficial reuse sites.

Table 8-15. Unit Cost for Biosolids Disposal and Reuse, \$/dry ton in 2008 \$

	Landfill	Local Land Application	Eastern OR Land Application
Liquid Biosolids	NA	130	1,000
Dewatered Biosolids[a]	180	30	220
Lime Stabilized Biosolids	60	10	70
Dried Biosolids[b]	30	5	40

(a) Assume 16% solids

(b) Assume 90% solids

The following should be considered in development of a biosolids reuse and disposal program:

- Land applying to City-owned property is the most reliable approach to a biosolids reuse program. Agreements with private landowners provide a level of reliability.
- There is a level of uncertainty associated with the continued and future availability of local sites.
- Risks with landfill disposal include the landfill capacity limits (i.e., the landfill will close) and termination of the agreement.
- Hauling to eastern Oregon can be interrupted by bad weather or work stoppages.