WASTEWATER FACILITY PLAN

Rural Improvement District 305
Gallatin - Madison Counties
Big Sky, Montana
September, 1986

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CONSULTING ENGINEERS/P

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WASTEWATER FACILITY PLAN

RID 305

BIG SKY, MONTANA

I. INTRODUCTION.

The purpose of this facility plan is to determine the current capacity of existing facilities and when improvements, i.e., additional aeration treatment, storage and spray irrigation facilities, will be required at Big Sky. This report concerns all property, which will eventually be connected to Big Sky's central treatment and disposal system. Development area, as it is defined in this report, will also include the court mandated reservation for Westlands, Inc. a planned development east of Highway 64 in the Meadow Village. The existing facility, with slight modifications, will adequately handle all projected growth, including Westlands, for the next five years.

The existing system has quite adequately treated and renovated all wastewater generated at Big Sky. Recent bacteriological and chemical tests this past spring show no contaminates whatsoever from the storage and disposal system impacting the Middle Fork of the West Gallatin River or domestic wells below the plant. Results of the recent chemical testing are bound in a report titled Bacteriological and Chemical Testing Results, Big Sky Sewer District, (June 25, 1986), which accompanies this facility plan.

Recent studies, which have reviewed the waste treatment issue at Big Sky include the 1982 Wastewater Facility Plan and a 1986 draft facility plan, both prepared by Morrison-Maierle Engineers. Where appropriate, this report incorporates excerpts from these reports.

II. POPULATION AND DEVELOPMENT PROJECTIONS.

The Big Sky Property Owners Association recently completed a summary listing of all present development within the District, and have developed a projection of all the future development, which can be served by the District. This tabulation is bound in the Appendix "A" of this document. In summary, there are 521 housing units presently constructed in the Meadow Village area. This includes both single family and condominium units in Sweet Grass Hills, West Fork Meadows, Hidden Village, the Mobile Home Village and Lone Mountain Guest Ranch. These units represent a design population of approximately 2158 people.

The Mountain Village has 753 existing housing units. This includes the single-family homes in Cascade Subdivision for a design population 2676. There are presently 15 commercial or governmental services in the Meadow Village area and 31 commercial or governmental services on the Mountain. For the most part, the people who work in the commercial areas live in the Meadow and Mountain areas. Sewage generated by them has been included in the residential categories.

The projection of future development indicates a potential for an additional 647 housing units in the Meadow, and 1401 housing units in the Mountain Village area. These units represent design populations of 3324 people, and 5306 people, for the Meadow and Mountain Villages respectively. In addition to this, the District Court of Gallatin County has mandated that sufficient waste water treatment, storage and spray irrigation capacity be reserved to handle an additional 3700 people, or 43 million gallons (MG) from Westlands, Inc. development.

As of this writing, Westlands, Inc. has not submitted any development plans to indicate immediate need for capacity in the system.

The existing sewage system for Big Sky is shown in Plate 1, bound at the back of this report.

III. INFILTRATION AND INFLOW.

The Big Sky Sewer District has been monitoring sewage and infiltration flows in the wastewater collection and trunk sewer system from the fall of 1985 through the summer of 1986. The volume of infiltration and inflow (I/I) flows for all areas on the Mountain and in the Meadow for the fall and winter of 1985-86 are noted in Table 8 of the report titled Preliminary Infiltration/Inflow Study, Big Sky Sewer System, January 1986. During this period infiltration averaged approximately 110 GPM (gallons per minute) at the sewage treatment plant (STP).

The study broke the entire Big Sky sewer system into a series of development nodes. Infiltration was monitored at regular intervals on the discharge end of these nodes. All nodes had some degree of infiltration. Those with the highest readings are scheduled for rehabilitation.

This initial phase of the Infiltration/Inflow (I/I) study points to two nodes contributing significant amounts of extraneous I/I flows. They are the Lake Levinsky sewer line along the west shore of Lake Levinsky on the Mountain, and the Yellowtail collector on Yellowtail Road in the Meadow. Rehabilitation work has started on the Yellowtail line, noticeably reducing infiltration here.

Infiltration rates increased as a result of the spring surface and groundwater runoff this past spring and summer. The measured I/I rates at the plant the first part of July showed readings as high as 190 GPM. This rate has steadily subsided since that time, primarily as a result of the repair of manhole leaks. As of September 1, 1986, infiltration was measured at 54 GPM.

If this rate continues this fall and winter, its safe to say rehabilitation measures thus far have reduced infiltration by at least 50 percent. Table 9 in the Preliminary Infiltration/Inflow Study (January 1986) for the Big Sky Sewer District lists infiltration rates of the plant during the late fall of 1985. Plate 2 lists infiltration by node over the course of 1985-86.

Rehabilitation: The District contracted this year with several industrial T.V. monitoring and sewer cleaning services and a manhole rehabilitation contractor. The T. V. work was a two-fold effort to remove heavy build-ups of debris and sludge in some of the lines and inspect pipe reaches suspected of leaks. A complete inventory and inspection of all manholes in the system was done concurrent with the TV inspection work. Inspection reports were completed for each manhole.

Manholes were first to be rehabilitated. The reason for starting with them is they are more accessible than the pipes. The majority of the leaks in manholes were detected in sidewall seams and in bases. Leaks were repaired through grouting techniques using polyurethane foam. A probe-type applicator was used to inject the grout directly into the leaks. All manholes in the entire system were physically entered with the exception of a small percentage buried under embankment, pavement or gravel.

TV inspection revealed a number of pipe leaks. They will be more difficult and costly to rehabilitate. Infiltration from pipelines is predominantly from the following types of pipe leaks:

-cracked pipes

-leaking off-set joints

-collapsed pipe

-service connections

Pipeline rehabilitation work, which is scheduled over the next four years, should conservatively reduce I/I by an additional twenty-five percent.

Efforts to repair pipe leaks thus far focused on the Yellowtail and Hidden Village nodes in the Meadow. Based on quick-insert type flume measurements this summer, the Yellowtail line alone is still responsible for nearly 35 gpm or nearly 50 percent of the remaining infiltration at the plant. The majority of this leakage in turn is attributed to a single household area drain, which is connected directly to the sewer. Lesser amounts of I/I were attributed to an uncapped branch on a service lateral, several joint leaks, and a punctured pipe section. The District is investigating alternatives to disconnect the area drain from the system. The service branch has been plugged. Work is underway to repair the pipe leaks through replacement.

The Hidden Village repairs focused on an off-set joint and a collapsed pipe section. Both have been repaired.

The preparatory cleaning work generally necessary before inserting the camera in the lines proved to be more extensive than originally anticipated. Several reaches, particularly the Lake line on the Mountain from Sitting Bull to Low Dog at Black Eagle and the outfall line at the plant, both had a heavy buildup of sludge, sand, gravel, rocks, mud and chunks of asphalt. Pipeline cleaning proved to be so extensive, due to the fact this is the first high pressure flushing any of the lines had received since the sewer collection system was installed.

Rehabilitation effectiveness: Rehabilitation efforts thus far have been successful in reducing infiltration on the order of fifty percent when compared to infiltration readings taken a year ago on September 1, 1985. Continued monitoring of early morning (4 A.M. to 6 A.M.) flows at the plant and the various nodes this fall will tell the long term success of repairs. As of September 1, 1986, infiltration rates have dropped from 100 - 110 gpm to 54 gpm. This represents a reduction from 158,000 gpd to 80,000 gpd, a savings of approximately 14 million gallons in winter storage requirement or 29 percent of the existing volume. The benefit of rehabilitation work this far has far outweighed the cost.

Per capita waste flow: The extent of future waste treatment and disposal improvements at the STP are in part dependent on the per capita volume of sewage by visitors and permanent residents. This rate, known as a population equivalent (P. E.) and expressed in gallons per capita per day (GPCD), represents the average combined volume of wastewater generated by overnight residents and day visitors (to include skiers and employees) at the resort. Because the area is a resort community, per capita sewage contributions are typically less than other municipalities.

To document per capita wastewater flows for wintertime use, Kerin and Associates prepared a report titled Per Capita Sewage Use Rates for the Big Sky Sewer District in March of 1986. With measured and recorded wastewater flows at key nodes in the system and corresponding accurate population counts from door to door surveys, Kerin and Associates was able to establish a conservative estimate of per capita wastewater flows of 45 to 50 gallons per capita per day (not including infiltration). For the purposes of this report, a rate of 50 gpcd is used for domestic sewage flow.

The selection of 50 gpcd is a conservative estimate when comparing the product of this rate and the peak occupancy of 4834 people to the maximum daily flows during the winter months. The actual raw sewage portion on the peak days for the past winter months averaged 192,000 gallons as listed below:

Month	Peak Flow (gpd)	Infiltration (gpd)	Raw Sewage (gpd)
December	365,000	158,400	207,000
January	342,000	158,400	183,600
February	344,000	158,400	185,600
Average	350,300	158,400	192,067

The per capita rate for this average sewage fraction when divided by a peak occupancy of 4834 people is actually only 39.6 gallons per capita per day.

Utilization Rate: In addition to the per capita use report, Kerin and Associates was also able to establish a conservative estimate for the resort's year-round utilization rate. Its invalid to assume that this development will operate at or even near 100 percent occupancy on a year round basis. Experience at Big Sky shows year round utilization is much less. This rate was studied extensively and found to be conservatively established at twenty-five percent for both summer and winter use. These rates were developed from door-to-door household occupancy counts, records from real estate management agencies at Big Sky, and reservation records from Boyne Mountain USA. The reservation records were made available for this report with the understanding they would not be formally published.

Sewage Flow: Based on recent observed infiltration rates of 55 gallons per minute or 80,000 gallons per day, and a per capita waste contribution of 50 gallons per day for an existing population of 4,834 people, the maximum daily wastewater flow, from existing development, is estimated at 321,700 gallons per day. Future repairs to reduce I/I in the system should reduce extraneous flows by an additional fifty percent. This means the combined raw sewage and I/I flow will be less than 300,000 gallons (domestic plus I/I flows) on a peak day.

The maximum daily wastewater flow at the plant at full development, including Westlands, Inc., is estimated to be 858,200 gallons per day. The waste flows are listing in Table 1.

TABLE 1

FLOW SUMMARY

Existing Development	Population Equivalent	GPCD	Total Flow
Mountain Village	2,676	50	133,800
Meadow Village	2,158	50	107,900
Mountain Commercial	110*		
Meadow Commercial	23 *		______
Subtotal	4,834		241,700
Future:			
Mountain Village	5,306	50	265,300
Meadow Village	3,324	50	166,200
Subtotal			431,500
Westlands, Inc.	3,700	50	185,000
Total	17,164		858,200

*See Pages 2 and 3

Based on a utilization rate of 25% and an average yearly infiltration rate of 80,000 gpd, the total annual wastewater flow at full development is projected to be 107.5 million gallons (MG) (858,200 x 0.25 x 365 + 80,000 x 365). This annual volume will be reduced as further repairs are made to the system.

IV. WASTEWATER TREATMENT SYSTEM.

The wastewater treatment system for Big Sky consists of three major processes:

1. Aeration
2. Winter Storage
3. Spray Irrigation

The system is designed to treat and dispose of wastewater generated by both the Meadow and Mountain Villages. The goal of the treatment plant is to remove the waste constituents: BOD_5, solids, nitrogen, and phosphorus to minimum levels, if not completely. If properly treated and disposed of, these constituents will not adversely affect the quality of ground and surface water. The fraction of BOD_5 and suspended solids (SS), that make their way into the spray irrigation system, is removed by the soil turf. Nitrogen and phosphorus removal is achieved through plant utilization and soil absorption. The aeration system reduces BOD_5 and SS (suspended solids) levels and provides nitrification of nitrogen (NH4 + NO3). The storage ponds provide retention of winter flows while providing additional nitrogen removal. Spray irrigation completes the nitrogen and phosphorus removal process as well as removing the balance of the BOD_5 and SS remaining after aeration and storage.

<u>1. Aeration System</u>: The aeration system consists of an 8.2 million gallon lined aeration pond. The aeration pond contains submerged fine bubble air diffuser pipes anchored to the floor of the basin cell. Based on the State of Montana Department of Health <u>Approved Wastewater Treatment Pond Design Guidelines</u> (minimum wastewater detention time of 15 days above the two foot level) the existing aeration pond is adequate to treat up to 500,000 gallons per day of wastewater. This figure is based on the following design parameters:

1. an average influent BOD_5 (Biochemical Oxygen Demand concentration, a measure of the quantity of organic material dissolved in wastewater), of 150 mg/l - 200 mg/l,
2. an aeration input of 800 cubic feet per minute,
3. an O_2 transfer efficiency rate of 8%,
4. a daily waste load contribution (150 ppm x 8.34 x 0.8 MGD) of 1000 lbs BOD_5/day,
5. oxygen applied = 1.5 lbs. O_2/lb BOD_5 removed,

$$SCFM = \frac{1500 \text{ lbs } O_2/\text{day}}{1440 \text{ min/day} \times 0.075 \text{ lbs./cf} \times 0.232 \times 0.08} = 750 \text{ SCFM}$$

where: 0.232 = % O_2 in air at standard conditions and

0.08 = O_2 transferred under field conditions.

With this the aeration system should be capable of providing sufficient oxygen to allow removal of up to 90% of the organic material during both the winter and summer for an estimated flow of approximately 800,000 gpd (1335 lb BOD_5/day).

If expansion needs are triggered on the basis of degree of treatment and effluent quality, the treatment cell should be able to adequately treat a wastewater flow including current I/I and 90 percent BOD_5 reduction for a population equivalence of 14,400 people ((800,000 gpd - 80,000 gpd)/50 gpcd), which is projected to occur in the year 2007. Reductions of I/I by an additional 50 percent will extend expansion of the aeration cell by an additional year to 2008, when population is expected 15,200 people.

2. Storage: Treated water from the aeration cell is stored during the winter for irrigation on the golf course during the summer months. In the past, treated water has been stored from 212 to 220 days. In the future, the treated water will not be stored longer than 181 days.

The existing storage volume is 48.7 MG. Storage cell no. 1 has a volume of 32 MG. Storage cell no. 2 has a volume of 16.7 MG. (See appendix B for computation of storage volumes).

The storage ponds are capable of storing an average daily wastewater flow of approximately 269,100 gallons. (48.7 MG divided by 181 days).

Average daily flow measured at the recorder for the period November 1, 1985 through February 28, 1986 was 224,055 gpd. Infiltration alone accounted for approximately 65 to 70 percent of this flow. Another year of flow records will document the long term success of recent flow reduction measures and establish with recorded data the average daily flow during the storage period. Sewer District personnel are continuing to keep daily records of plant flows.

The existing storage facilities are projected to serve Big Sky through the year 2008, when P. E. is projected to reach 15,100 people ((48.7 MG - 14.48 MG)/(50 x 181 x 0.25)). Further reduction to extraneous flows in the collections system will extend the life of the existing storage cells. The third cell may never be required. If infiltration is reduced another fifty percent, to 40,000 gpd, for example, storage volume requirement for all anticipated development (17,164 people) at Big Sky, which includes Westlands, will only reach 46.2 MG (17,164 x 50 gpcd x 181 +40,000 x 181).

3. Spray Irrigation System: The spray irrigation system is designed such that nearly all the nutrients (nitrogen and phosphorus) generated in the wastewater will be removed before the percolate reaches any receiving stream. The central design

considerations for the irrigation are both hydraulic and nitrogen loadings. A further consideration in the design of a spray irrigation system is control of the size of the spray site and amount of spraying so grasses can be maintained by the volume of wastewater applied during abnormally dry growing seasons and also during wet periods.

The Meadow Village Golf Course fairways are seeded to Kentucky bluegrass and the greens are seeded with Penncross and Penneagle bent grasses. Total existing irrigated acreage is approximately 100 acres. Additional undeveloped land is available within Meadow Village for a third nine-hole course. Total undeveloped land in the Meadow Village which could be irrigated is an additional 100 acres. Another source of land for additional spray sites is the future open spaces in the Westlands Development.

Based on EPA's design manual Land Treatment of Municipal Wastewater, phosphorus loadings are not a critical consideration in slow rate irrigation systems.

Design Criteria: The following criteria were used in the design of the spray irrigation system:

Total Annual Wastewater Volume	107.5 million gallons (329 acre feet)
Total Annual Nitrogen Load (Average Nitrogen Concentration 30 mg/l)	26,900 lb

Total Annual Phosphorous Load (Average Phosphorus Concentration 8 mg/l)		7,200 lb
Recurrence Interval of Seasonal Precipitation		10 years
Total Seasonal Precipitation (May - Oct.)		17.0 inches
Monthly Precipitation:	May	3.32 inches
	June	4.21 inches
	July	2.12 inches
	August	3.41 inches
	September	2.10 inches
	October	1.84 inches
Total Seasonal Effective Precipitation (May - Oct.)		6.13 inches
Monthly Effective Precipitation:	May	1.13 inches
	June	1.52 inches
	July	0.93 inches
	August	1.30 inches
	September	0.79 inches
	October	0.46 inches
Total Seasonal Evapo-transpiration (May - Oct.)		21.0 inches
Monthly Evapo-transpiration:	May	2.66 inches
	June	4.14 inches
	July	5.76 inches
	August	4.77 inches
	September	2.60 inches
	October	1.07 inches
Maximum Nitrogen Concentration Applies		30 mg/l
Percolate Nitrogen Concentration (Class 1-Groudwater)		<10.0 mg/l

Limiting Soil Percolation Rate	2.0 - 6.0 in./hour
Normal Crop Nutrient Requirements:	
Nitrogen	180 - 200 lb/acre/yr.
Phosphorous	20 lb/acre/yr.

Total Wastewater Flows and Loading: Probably the most critical parameter in designing the spray irrigation system is the estimate of the total volume of wastewater generated annually. As mentioned previously, to insure healthy fairways and greens for the life of the project, neither too much nor too little water can be applied.

Annual sewage flow is estimated to be 107.5 million gallons. Using 30 mg/l total nitrogen and 8 mg/l total phosphorous concentrations, total loads for these nutrient constituents have been previously established at 26,900 lbs/year and 7,200 lbs/year for nitrogen and phosphorus, respectively.

Monitoring of the total annual wastewater volume through the daily flow recorder at the treatment plant is planned as an operational procedure to ascertain the need for adding to the area under irrigation. The District is planning to add some additional sprinkler heads as early as next year to irrigate some more area. As previously mentioned, healthy fairways and greens depend on just the right amount of water.

Precipitation Data: Sufficient area must be allocated for irrigation in abnormally hot, dry growing seasons. The MDHES criteria is to design on the "wettest year in 10".

To establish this value, 26 years of data from the U. S. Weather Bureau's weather station near Big Sky was analyzed. Only values pertaining to the growing season (May through October) were used. The ten year recurrence interval precipitation was established at 17.0 inches using Gumbell's probability methods (Engineer News-Records, Vol. 134, pp. 833-837, 1945). This figure was allocated monthly based on the value of the average monthly total to the average growing season precipitation, as defined on page 4-29 of EPA's Manual for Land Treatment of Municipal Wastes.

1. Effective Precipitation: Effective precipitation is that portion of the actual precipitation which becomes soil water, located in the saturated, capillary fringe above the water table. This is the only moisture available to a plant to satisfy its consumptive use (evapo-transpiration) requirements. The application of irrigation water must, therefore, reflect this contribution.

Effective precipitation is difficult to estimate. A general method of estimating this value has been developed by the U. S. Soil Conservation Service utilizing a modified Blaney-

Criddle Procedure. Monthly values for effective precipitation at Big Sky are listed on pages 14 and 15 of this report.

2. <u>Irrigation Area</u>: Area required for irrigation of the wastewater for the total development is estimated to be 194 usable acres. This area does not include buffer zones along streams. Land available in the Meadow for irrigation is estimated to be 200 acres. The existing irrigable land totals 100 acres. Should Westlands develop, the District should arrange to irrigate open spaces there in lieu of irrigating the golf course roughs or pasture, where irrigation will be of little benefit.

The irrigable area required was established from net application rates. The application rate was determined using three separate methods. The critical application rate was determined to be the smallest of the three. The methods are:

1. Vegetation requirement
2. EPA Hydraulic Loading
3. EPA Hydraulic Loading - Nitrogen Limiting

The vegetation requirement method utilizing a minimum application rate of 20.17 inches per growing season (21" + 5.3" - 6.13") was used as the basis for design. The effective precipitation was based on the 10 year growing season precipitation. A field efficiency of 75 percent was used to account for sprinkler head evaporation, aerosol losses and leaching losses. This method results in a hydraulic loading rate of 1.70 acre feet per acre and a usable acreage requirement of 194 acres. The current irrigated land and available area are shown on Plate 3.

The allowable annual hydraulic loading rate increases to 1.20 mg per growing season based on EPA's criteria for nitrogen limitations. This same analysis showed a maximum acceptable nitrogen loading rate of 312 pounds per acre per year. These application rates are based on the following criteria:

1. Maximum percolate nitrogen concentration of 10 mg/l (Class 1 Groundwater),
2. Effluent wastewater nitrogen concentration of 30 mg/l,
3. Crop nitrogen uptake of 180 pounds per acre per year,
4. Denitrification of 10 percent of applied nitrogen,
5. Hydraulic and nitrogen balance based on May through October period,
6. Surface runoff essentially zero during this period,
7. Ten year precipitation during this period 17 inches, and
8. Crop consumptive water use of 21 inches during this period;

The allowable annual hydraulic loading rate, based on nitrogen loading limits $= \frac{10(43.18 \text{ cm} - 53.34 \text{ cm}) + 201.6\ (10)}{(1 - 0.10)(30) - 10} = 112.6\ \frac{\text{cm}}{\text{Yr}}$

or 1.20 mg/acre/Yr.

The total annual nitrogen loading rate, in kg/HA/Yr = 10 x 30 x 1.13 = 336 kg/HA/Yr or 300 lb/AC/Yr

where:

1.13 = annual loading rate, m/Yr

43.18 cm = annual precipitation rate in cm/Yr (17"/year)

53.34 cm = evapo-transpiration rate in cm/Yr (21"/year)

201.6 = nitrogen uptake by crop in kg/HA/Yr(180 lb/ac/yr)

10 = nitrogen concentration in percolate (mg/l)

0.10 = fraction of applied nitrogen removed by denitrification and volitilization

30 = nitrogen concentration in applied wastewater in mg/l

Based on a 26 week irrigation period, the average weekly application rate would be approximately 2.0 inches. Soils at Big Sky exhibit permeabilities in this range. This nitrogen limiting procedure does not, however, generate the critical or smallest application rate. The vegetation requirement does and should be used on the basis to design the expansion to the spray system.

Based on hydraulic loading rates using the vegetative requirement method, the existing 100-acre golf course would be able to accommodate 55.4 MG of wastewater per year (100 AC x 1.7 af/ac x 43560 ft^2/ac x 7.48 gal/ft^3). The total available land for spray irrigation in the Meadow, i.e., 200 acres, can accommodate nearly 111 mg annually, which exceeds the projected annual volume of 107.5 MG.

V. FUTURE TREATMENT, STORAGE AND DISPOSAL FACILITIES

The existing system, as shown on Plate 4, has adequately treated, stored and renovated through spray irrigation the wastewater generated at Big Sky. The system, with minor improvements, will adequately serve Big Sky's growth until the population equivalency of 5,750 people, which is predicted to be the year 1989. When the design population reaches equivalence the spray irrigation system will require expansion. It was stated above the existing irrigated ground can handle an estimated 55.4 MG. A P. E. of 5,750 is projected to generate this volume (5750 P. E. x 50 gpcd x 0.25 x 365 days + 80,000 gpd x 356 = 55.4 MG). Successful repairs the District scheduled rehabilitation work on already detected leaks will set this date further back. For instance, if scheduled repairs further reduce I/I by an additional fifty percent to 40,000 gpd, total annual wastewater volume will be reduced to 40.9 MG. If this were to occur, expansion of the irrigation system would not have to occur until the P. E. reaches 8,940 people, which is not projected to occur until 1998.

Assuming the existing method of wastewater treatment and disposal is utilized to treat and dispose future wastewater flows, a total of 15.9 MG in aeration pond, 53.5 MG in storage, and 194 acres of suitable application area will be required. These figures are based on the following generalized computations:

Aeration:

938,200 gpd x 15 days = 14.1 mg

+ 2 ft for sludge = 1.8 mg

Accumulation 15.9 mg

Winter Storage -

Sewage: 858,200 gpd x 181 days x 0.25 (utilization) = 39.0 mg

Infiltration: 80,000 gpd x 181 days = 14.5 mg

53.5 mg

Irrigation -

330 af/1.70 af/acre = 194 acres

Growth is projected to occur at a steady uniform rate. The District will have ample time to set aside the funds for any needed payments through revenues to stage construction as needed. If Westlands plans immediate development, which would accelerate growth to a P. E. of 8,534 people, the District would only have to step up construction of the irrigation system improvements to irrigate an addition 25 acres of golf course area. As of this writing, the District is contemplating expanding the irrigation system to some course areas, which could already use irrigation. Generally speaking, facilities will deteriorate if capacity is built into them now and not used immediately.

Plate 4 is an overlay of Plate 3. It shows the proposed modifications to the existing plant, including enlarged aeration and storage cells and a layout of the third storage cell if necessary to the east. The third cell could also be used for an aerated treatment cell in lieu of raising the dike of the existing aeration cell.

Geotechnical investigation of the existing pond site has determined that it would be feasible to enlarge the existing aeration cell no. 2 to 15.9 MG and storage cells to 71.6 MG by raising the dike around existing storage cell no. 1 approximately eight feet. Storage cell no. 2 could be lowered an additional eight feet for a volume of 20.1 MG. While raising the dikes of cell no. 1 is a viable alternative, the Big Sky Sewer District prefers lowering cell no. 2 or building a third cell. When the Sewer District needs the additional storage volume and its Board elects not to raise the dikes of the existing cell, there are other alternate sites available, including the following areas:

1. A third cell just to the east of the existing cell no. 1, shown on Plate No. 4.
2. A natural depression just north of Hidden Village
3. The site of a temporary sewage lagoon constructed when the sewer utility was first built in 1973.

All sites have been evaluated, as suitable with proper geotechnical design considerations.

The combined potential volume of storage cells no. 1, no. 2 and no. 3 is 85.3 MG. The ability of the existing cells to meet the long range storage needs of the District will depend on removing additional extraneous flows (I/I) and extending the existing irrigation season. Arrangements to extend the irrigation season have been made with Sewer District and Big Sky, Inc. personnel. Spraying in the golf course and surrounding roughs will start around the first of May and run until the end of October. In addition to extending the life of the existing storage, extending the irrigation season will provide additional moisture for early spring growth of the golf course grass.

While occupancy and usage patterns at Big Sky could change future aeration and storage requirements, total available storage at the existing District-owned site will meet requirements based on assumptions in this report. Even though maximum wastewater flows occur during the middle of the wastewater storage period, the existing site should be able to provide adequate volume to treat and store the projected wastewater flows. Per capita flows and occupancy rates would have to drastically change to require storage beyond the available 85.3 MG.

As discussed previously, there is approximately 200 acres of undeveloped land within Meadow Village suitable for wastewater irrigation. Based on a computed hydraulic loading rate of 1.70 acre feet per acre per year, this land should be adequate to dispose of the projected yearly wastewater volume of 107.5 MG.

Application rates could even be increased if necessary without jeopardizing groundwater quality. Application rates will depend in part on the ability of the grasses to accommodate additional water.

VI. SCHEDULE OF REQUIRED IMPROVEMENTS

The schedule of design populations that will trigger improvements, when required, to the wastewater treatment, storage, and disposal facilities is illustrated in Table 2. As discussed in the text of this report, design capacity of each of these three components can be extended by decreasing infiltration and inflow in the system. Estimated construction dates are based on population growth of five percent per year. This growth rate does include Westlands, Inc., which presumably would grow at the same rate as the rest of Big Sky.

If the District is expected to reserve capacity now for Westlands, Inc., they would have to expand only the spray irrigation system to accommodate current needs plus Westlands. As pointed out earlier, the existing aeration treatment system would be able to adequately treat a wastewater volume of 800,000 gpd, which is equivalent to a population equivalent of 14,400 people, which is projected to occur in 2007. With infiltration and inflow reduction measures pointed out in this report, this date could be expanded.

It should be noted that the estimated date of construction is one year prior to the date that the population will reach the design population improvement. Construction costs are based on 1986 dollars (ENR Index 4210).

A summary of maintenance repair to further reduce infiltration is listed in Table 3.

Table 2

SUMMARY OF REQUIRED IMPROVEMENT

BY DESIGN POPULATION

AND ESTIMATED CONSTRUCTION COST

Date	Aeration Treatment	Storage	Spray Irrigation
1986	14,400 P.E.[1]	15,100 P.E.	5,750 P.E.[3] ($30,000)
1989			5,750 P.E.
1996			8,534 P.E ($30,000)
2003			11,792 P.E. ($30,000)
2007	14,400 P.E.[2] ($500,000)[4]		
2008	15,100 P.E.	15,100 P.E. ($400,000)	15,100 P.E. ($30,000)
2011	17,164 P.E.	17,164 P.E.	17,164 P.E.

[1] P.E.: Population Equivalent
[2] Treatment capacity of current aeration system can be extended one year by reducing I/I by additional 50% to 40,000 gpd
[3] In order to provide reserve capacity for Westlands, Inc., the spray site must be expanded an additional 25 acres. The District will stage irrigation improvements in lieu of installing them all at once.
[4] 1986 construction cost (ENR 4210)

Table 3

SUMMARY OF MAINTENANCE REPAIRS

Required Improvements	Design Population	Estimated Construction Date	Construction Cost
1. Infiltration Reduction Measures:	4,834		
A. Chemical grout seal along 300 L.F. of lake line - Mountain Village		1986-1990	7,000
B. Repair detected pipe leaks, Meadow and Mountain Village		1986-1990	10,000
C. Additional TV inspection and flushing			10,000
D. Repair service leaks - Mountain Village		1986-1990	4,000
E. Repair leaks in Yellowtail collector		1986-1990	3,000
F. Disconnect area drain - Yellowtail collector		1986-1990	5,000
G. Additional manhole rehabilitation and re-placements		1986-1990	15,000

APPENDIX A

Existing and Proposed Development

Meadow Village

Mountain Village

AREA EXISTING DEVELOPMENT:	UNITS	BEDROOMS	PEOPLE	FLOW
Meadow Village Homes	72	216	432	21,600
Silver Bow Condos (T1 & 1A)	70	147	294	14,700
Park Condos (T2)	12	24	48	2,400
Yellowstone Condos (T3)	42	72	144	7,200
Teton Condos (T4)	3	9	18	900
Glacier Condos (T7)	66	136	272	13,600
Broadwater Condos (T9)	16	24	48	2,400
Telemark Inn	21	21	42	2,100
Chase Montana Building	6	8	16	800
Commercial	15			
Sweet Grass Hills Homes	17	51	102	5,100
West Fork Meadows	35	49	98	4,900
Hidden Village	94	217	434	21,700
Lone Mountain Ranch	32	35	70	3,500
Mobile Home Village	35	70	140	7,000
SUBTOTAL			2,158	107,900
PROPOSED DEVELOPMENT:				
Meadow Village Homes	152	456	912	45,600
Teton Condos Add.	34	75	150	7,500
Tract 5 (1.79 A)	22	48	96	4,800
Tract 6 (4.22 A)	50	110	220	11,000
Tract 8 (5.35 A)	64	140	280	14,000
Tract 11 (5.08 A)	60	132	264	13,200
Tract E (1.65 A)	20	44	88	4,400
Tract D (Homes)	24	72	144	7,200
Sweet Grass Hills Homes	73	219	438	21,900
Section 35 Unplatted Homes	40	120	240	12,000
West Fork Meadows	62	136	272	13,600
Hidden Village	36	80	160	8,000
Blue Grouse Hills	10	30	60	3,000
Westlands, Inc.			3,700	185,000
SUBTOTAL			7,024	351,200
TOTAL			9,182	459,100

NOTES:
1. 3 bedrooms assumed per single family home
2. 12 condos per acre assumed on undeveloped condo tract
3. 2.2 bedrooms assumed per proposed condo
4. Sewage flow based on per capita contribution of 45 GPD

AREA	UNITS	BEDROOMS	PEOPLE	FLOW
EXISTING DEVELOPMENT:				
Cascade Subdiv. Homes	11	33	66	3,300
Hill Condos	180	213	426	21,300
Stillwater Condos	64	96	192	9,600
Deer Lodge Condos	124	247	494	24,700
Lake Condos	29	72	144	7,200
Beaverhead Condos	12	36	72	3,600
Arrowhead Condo	14	42	84	4,200
Skycrest Condo	35	75	150	7,500
Huntley Lodge	204	408	816	40,800
Mountain Lodge	44	44	88	4,400
Employee Housing	36	72	144	7,200
Commercial	31			
SUBTOTAL			2,676	133,800
PROPOSED DEVELOPOMENT:				
Cascade Subdiv. Homes	74	222	444	22,200
Deer Lodge Condos	130	260	520	26,000
Lake Condos Add.	45	112	224	11,200
Beaverhead Condos Add.	36	108	216	10,800
Skycrest Condos Add.	300	660	1,320	66,000
Tract 1 (5.77 A)	70	154	308	15,400
Tract 2 (8.98 A)	110	242	484	24,200
Tract 4 (3.06 A)	36	79	158	7,900
Tract 5 (28.22 A)	338	744	1,488	74,400
Employee Housing Add.	36	72	144	7,200
Upper Cascade Homes	226	678	1,356	67,800
SUBTOTAL			5,306	333,100
TOTAL			7,982	466,900

NOTES:
1. 3 bedrooms assumed per single family home
2. 12 condos per acre assumed on undeveloped condo tract
3. 2.2 bedrooms assumed per proposed condo
4. Sewage flow based on per capita contribution of 45 GPD

APPENDIX B

Volume Computations

Treatment and Storage Cells

Appendix B
VOLUMES - EXISTING CELLS

I. Aeration - Treatment Cell

Planimeter Constant - $\frac{0.095}{In^2}$ = 10,000 SF

Side Walls - 3:1

Water Surface - 6,174.5 feet

Bottom Elevation - 6,160.5 feet

Average Depth - 14.0 feet

Area - Water Surface - $(\frac{1.02}{In^2} \times 10{,}000)/0.095 = 107{,}368\ Ft^2$

Area - Bottom - $(\frac{0.47}{In^2} \times 10{,}000)/0.095 = 49{,}473\ Ft^2$

Average = $78{,}420\ Ft^2$

Volume - $78{,}420\ Ft^2 \times 7.5\ \frac{Gal}{Ft^3} \times 14\ Ft = 8.2\ MG$

II. Storage Cell No. 1

Side Walls - 3:1

Water Surface - 6,174.5 feet

Bottom Elevation - 6,158.5 feet

Average Depth - 16.0 feet

Area - Water Surface - $(\frac{3.02}{In^2} \times 10{,}000)/0.095 = 317{,}895\ Ft^2$

Area - Bottom - $(\frac{2.01}{In^2} \times 10{,}000)/0.095 = 211{,}579\ Ft^2$

Average = $264{,}734\ Ft^2$

Volume - $264{,}734\ Ft^2 \times 7.5\ \frac{Gal}{Ft^3} \times 16\ Ft = 13.8\ MG$

Use 32 MG

III. Storage Cell No. 2

Side Walls - 3:1

Water Surface - 6,185 feet

Bottom Elevation - 6,167 feet

Average Depth - 18 feet

Area - Water Surface - $(\frac{1.8}{In^2} \times 10{,}000)/0.095 = 189{,}473.6\ Ft^2$

Area - Bottom - $(\frac{0.47}{In^2} \times 10{,}000)/0.095 = 57{,}895.0\ Ft^2$

Average = $123{,}684.0\ Ft^2$

Volume - $123{,}684\ Ft^2 \times 7.5\ \frac{Gal}{Ft^3} \times 18\ Ft = 16.7\ MG$

VOLUMES - FUTURE CELLS

I. Storage Cell No. 1 - Raise Existing Dike 8.0 Feet

Side Walls - 3:1

Water Surface - 6,185.0 feet

Bottom Elevation - 6,158.0 feet

Average Depth - 27.0 feet

Area - Water Surface - $(\frac{3.16}{In^2} \times 10{,}000)/0.095 = 332{,}158\ Ft^2$

Area - Bottom - $(\frac{1.76}{In^2} \times 10{,}000)/0.095 = 176{,}842\ Ft^2$

Average = $254{,}500\ Ft^2$

Volume - $254{,}500\ Ft^2 \times 7.5\ \frac{Gal}{Ft^3} \times 27\ Ft = 51.5\ MG$

II. Storage Cell No. 2

Side Walls - 3:1

Water Surface - 6,185.0 feet

Bottom Elevation - 6,160.0 feet

Average Depth - 25.0 feet

Area - Water Surface - $(\frac{1.76}{In^2} \times 10{,}000)/0.095 = 185{,}263\ Ft^2$

Area - Bottom - $(\frac{0.28}{In^2} \times 10{,}000)/0.095 = \underline{29{,}474}\ Ft^2$

Average $= 107{,}368\ Ft^2$

Volume - $107{,}368\ Ft^2 \times 7.5\ \frac{Gal}{Ft^3} \times 25\ Ft = 20.1\ MG$

III. Storage Cell No. 3

Side Walls - 3:1

Water Surface - 6,175.0 feet

Bottom Elevation - 6,155.0 feet

Average Depth - 20.0 feet

Area - Water Surface - $(\frac{1.284}{In^2} \times 10{,}000)/0.095 = 135{,}252\ Ft^2$

Area - Bottom - $(\frac{0.45}{In^2} \times 10{,}000)/0.095 = \underline{47{,}368}\ Ft^2$

Average $= 91{,}310\ Ft^2$

Volume - $91{,}310\ Ft^2 \times 7.5\ \frac{Gal}{Ft^3} \times 20\ Ft = 13.7\ MG$

IV. Aeration Cell - Raise Existing Dikes by 8 Feet

Side Walls - 3:1

Water Surface - 6,185.0 feet

Bottom Elevation - 6,161.0 feet

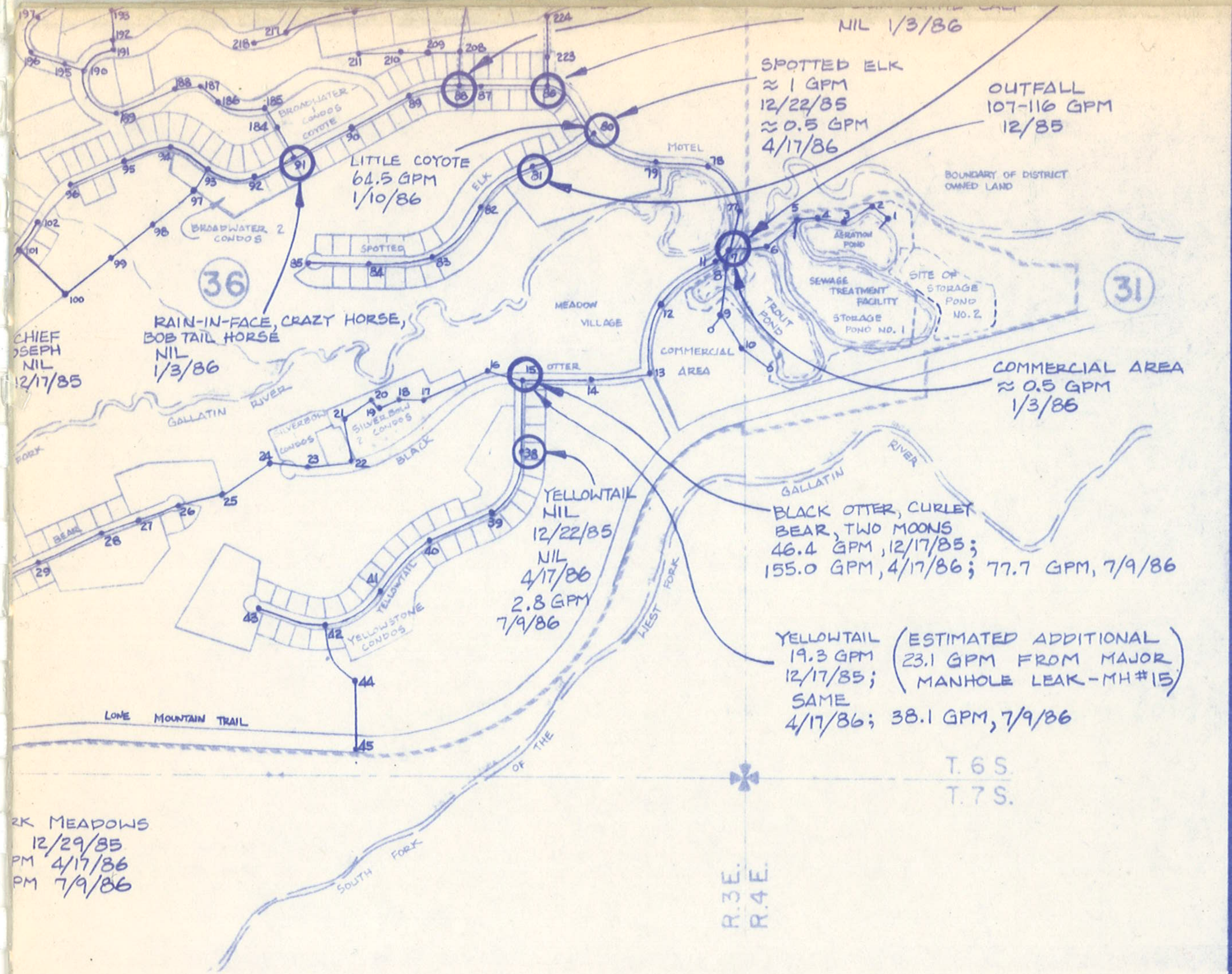
Average Depth - 24.0 feet

Area - Water Surface - $(\frac{1.35}{In^2} \times 10{,}000)/0.095 = 142{,}105\ Ft^2$

Area - Bottom - $(\frac{0.332}{In^2} \times 10{,}000)/0.095 = 34{,}948\ Ft^2$

Average = $88{,}562\ Ft^2$

Volume - $88{,}562\ Ft^2 \times 7.5\ \frac{Gal}{Ft^3} \times 24\ Ft = 15.9\ MG$



R.I.D. 305 BIG SKY MONTANA
WASTEWATER FACILITY PLAN

INFILTRATION NODAL MAP

9/12/86
PROJECT NO. 12-86

PLATE 2

DRAWN BY: M.K.
APPROVED BY: R.K.

KERIN & ASSOCIATES

CONSULTING ENGINEERS/PLANNERS

R.I.D. 305 BIG SKY, MONTANA
WASTEWATER FACILITY PLAN

SITE PLAN-EXISTING SEWAGE TREATMENT PLANT

9/12/86
PROJECT NO. 12-86

PLATE 3

DRAWN BY: M.K.
APPROVED BY: R.K.

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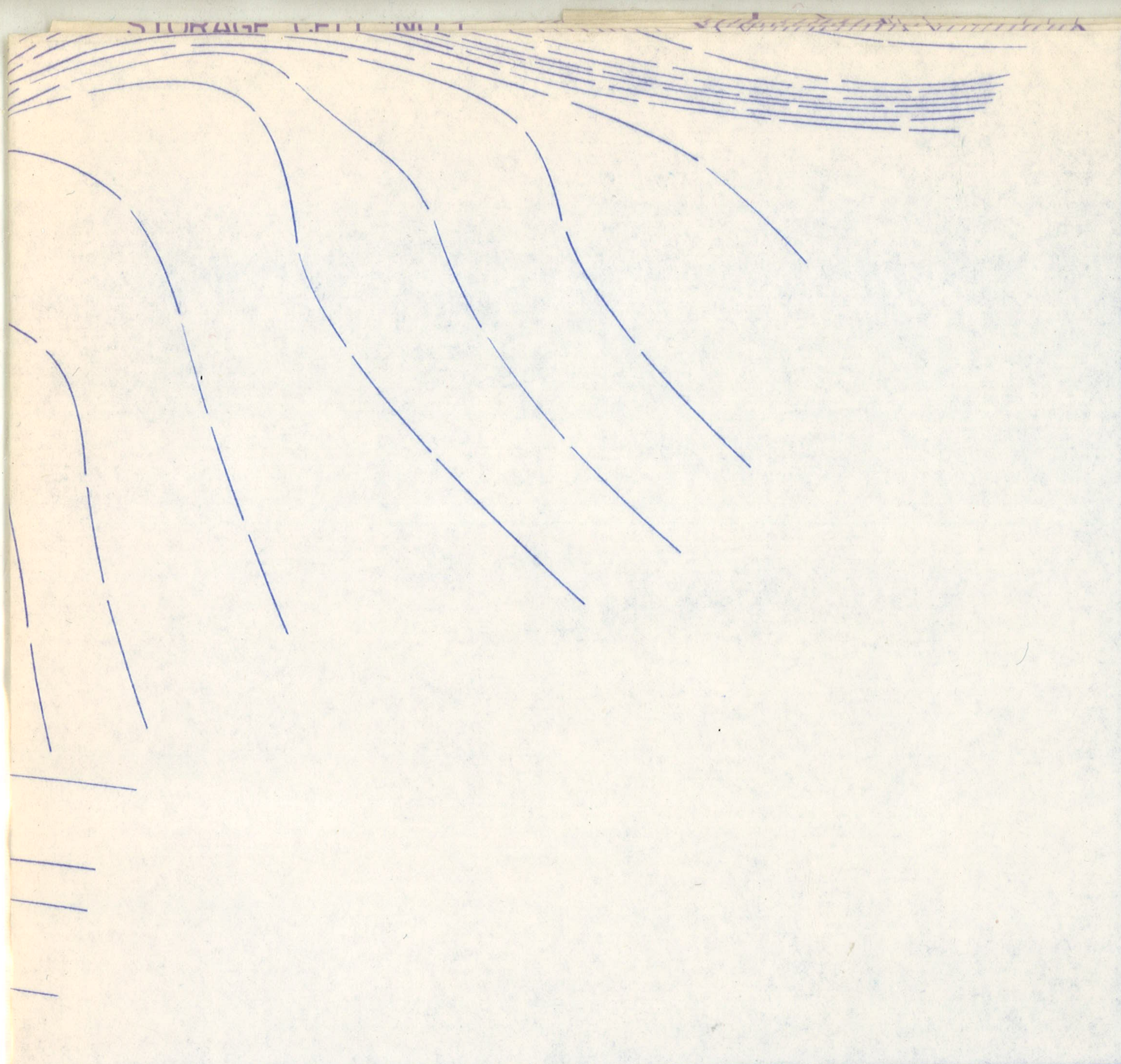
219 E. Mendenhall St., Bozeman, MT 59715



R.I.D. 305 BIG SKY, MONTANA
WASTEWATER FACILITY PLAN
SITE PLAN-TREATMENT PLANT EXPANSION

9/12/86
PROJECT NO. 12-86

PLATE 4

DRAWN BY: M.K.
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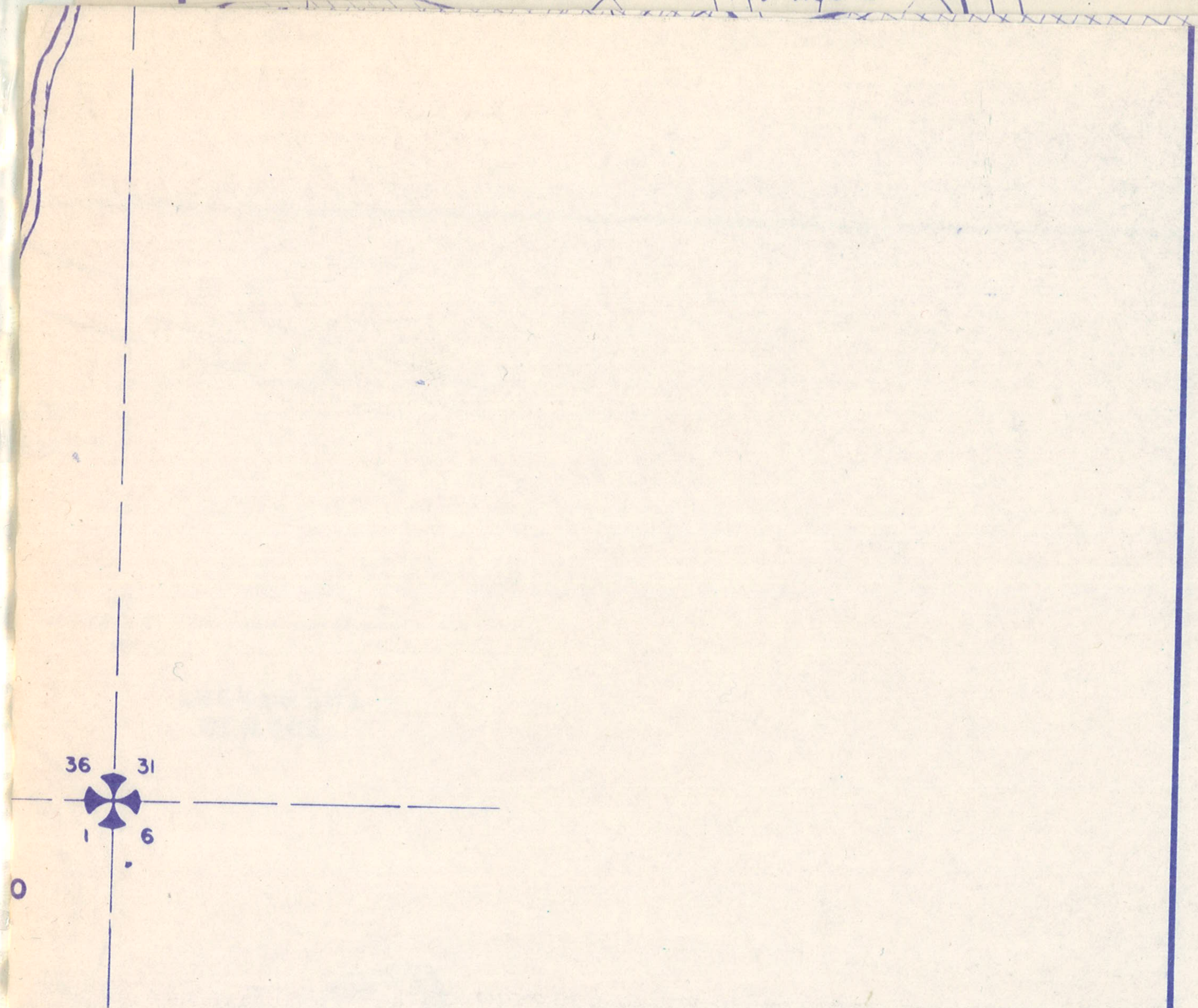

R.I.D. 305 BIG SKY, MONTANA
WASTEWATER FACILITY PLAN

SPRAY IRRIGATION SITE

9/12/86
PROJECT NO. 12-86

PLATE 5

DRAWN BY: F.R.
APPROVED BY: R.K

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