MUNICIPALITY OF METROPOLITAN SEATTLE

King County, Washington

FINAL REPORT
GEOLOGIC AND HYDROLOGIC CONDITIONS
SLUDGE DISPOSAL SITE(S)
NEAR RAVENSDALE, WASHINGTON

September, 1972

Metropolitan Engineers, Consulting Engineers
100 West Harrison
Seattle, Washington
98119

Ron Free

METROPOLITAN ENGINEERS

100 WEST HARRISON · SEATTLE, WASHINGTON 98119 · 284-5100

A JOINT VENTURE OF
BROWN AND CALDWELL
CAREY AND KRAMER
HILL & INGMAN
R. W. BECK AND ASSOCIATES

September 14, 1972

Municipality of Metropolitan Seattle
410 West Harrison Street
Seattle, Washington 98119

M231K-19

ATTENTION: Mr. C. J. Henry
Director of Waste Water

FINAL REPORT
GEOLOGIC AND HYDROLOGIC CONDITIONS
SLUDGE DISPOSAL SITE(S)
NEAR RAVENSDALE, WASHINGTON

Enclosed is our final report on the geologic and hydrologic conditions at the Ravensdale site as requested in your letter of February 3, 1972. We have made field studies of the area and we have conducted an exhaustive search of local mining records and other pertinent publications. We believe this site is suitable for the disposal of dewatered digested sludge provided extensive precautions are taken to prevent ground water contamination. Such measures might include sterilization of the sludge and sealing the bottom of any abandoned strip mines. Certain hydrologic anomalies exist at the site which indicate that an expensive program would be necessary to insure a positive seal between the deposited sludge and the ground water.

We will be happy to discuss any part of our study with your staff at your convenience.

METROPOLITAN ENGINEERS

Roger F. Wilcox
Chief Engineer

Eugene R. McMaster
Chief Foundation Engineer

RFW/ERM:pa

encl.

INTRODUCTION

This report contains the results of our evaluation of the geologic and hydrologic conditions underlying the abandoned coal surface strip mine being considered by you for the land disposal of digested sludge. As indicated on the Vicinity Map, Plate 1, the site is some 40 miles southeast of Seattle near the town of Ravensdale. Designated as the Dale Strip Pit on Plate 2, the site is located in the N.W. 1/4 of Section 1, Township 21, Range 6 East on a bedrock hill which rises to heights ranging from 200 feet to 400 feet above the adjacent lowland. Approximately 1800 feet long and over 40 feet deep, at some points, the volume of the Dale Strip Pit is estimated to be in excess of 250,000 cubic yards. Possible alternate sites in the N.E. 1/4 and the S.E. 1/4 of Section 1 are designated as McKay Strip Pit 6 and McKay Strip Pit 7, respectively.

The purpose of this investigation, as stated by your authorizations of February 3, 1972 and March 31, 1972, was to analyze the geologic formations and hydrologic site performance relative to the planned use of digested sludge disposal. The basis for our evaluation was detailed field reconnaissance of the area by our geologist together with the utilization of available published geologic maps, old mine maps and the stereoscopic examination of low level aerial photos. Various publications related to coal mining in the area were reviewed and supplemented by interviews with the former superintendents of both the underground and strip mining coal operations. Relevant files of the Burlington Northern Railroad, the State Mine Inspector, and the Division of Mines and Geology of the Washington State Department of Natural Resources were also examined. Data obtained from a limited water quality study by you was made available to us. Test borings and test wells, while authorized by you, were not drilled for reasons discussed later.

GEOLOGY

As shown by the topographic contours on Plate 2, the Dale Strip Pit lies at about elevation 920* near the westerly flank of the bedrock hill just south of Ravensdale. A thin (2 to 10 feet) layer of glacial till, consisting of clay, sand, cobbles and boulders, unconformably blankets much of the bedrock comprising the hill. The underlying bedrock is mapped as the nonmarine sedimentary rocks of the Puget Group. Of probable late Eocene age, the Puget Group is composed of sandstone and siltstone with numerous carbonaceous shale and coal beds and minor amounts of claystone and conglomerate. All gradations between sandstone and siltstone are present, and most of the rocks are either silty sandstone or sandy siltstone. The sandstone beds are typically yellowish gray to light olive gray, fine grained, micaceous, and

* elevation 0 = mean sea level (MSL)

arkosic or feldspathic, but, in the vicinity of the Dale Strip Pit, some are quartz-rich and weathered. Most of the sandstone beds are cross-laminated and form massive outcrops. Some beds are ripple marked, and convolute bedding and intraformational breccia occur in a few places. The siltstone beds commonly are medium light gray to dark gray and contain varying amounts of finely disseminated carbonaceous fragments.

The structure of the Puget Group in this general vicinity is quite complex, with much folding and faulting, as shown on Plate 3. In Section 1, T22N, R6E, the beds of the Puget Group have been folded into a west-plunging syncline with the synclinal axis located just south of the Dale Strip Pit and trending about N 80° W. The bedding on the north limb of the syncline strikes N 30° W and dips approximately 50° to the west. On the south limb, the bedding strikes S 45° W and dips slightly steeper at about 60° to the northwest. The syncline is terminated at about the north and south section lines of Section 1 by major faults.

MINING HISTORY

The various coal seams within the Puget Group have been mined extensively throughout much of King County. Geologic maps show that considerable underground mining of certain of these seams was carried out in the Ravensdale area (Plate 3). Of specific interest are the Dale No. 4 and Dale No. 7 seams and the McKay seam which were also strip mined along their surface outcrops.

Dale No. 4 and Dale No. 7 Seams

On the basis of careful examination of a map of the Dale No. 1 mine (Plate 4) as well as from discussions with the former superintendent of the underground mining operation and the superintendent of the stripping operation, and from the various published maps and reports of the area, the following information has been collected:

Both the Dale No. 4 seam and the Dale No. 7 seam (which lies approximately 200 feet stratigraphically below the number 4) were worked underground in the Dale No. 1 mine from 1924 to at least 1932. The portal of the mine is located in the north flank of the hill some 2,000 feet northwest of the Dale Strip Pit at elevation 675 mine datum**. From the portal, the entry tunnel was driven 1,500 feet or so along, at least partially, an unnamed coal seam overlaying the Dale No. 4 seam. From that point, a crosscut was driven easterly to intercept the No. 4 and the No. 7 seams and then a gangway was driven along each seam out to the

** While the old mine map elevations supposedly are referring to mean sea level, there appears to be a discrepancy of about 40 feet at common surface points when compared to USGS Mean Sea Level maps. It is assumed that Elev. 0 MSL= elev. 40 md (mine datum).

southerly limits of the Dale workings as shown on Plate 4. The entire Dale No. 1 mine was constructed as a self-draining mine; that is, with the portal the lowest point in the mine. Ground water, which was encountered, was allowed to drain by gravity from the workings through the tunnel (water-level drift) and out the portal. The gangways were driven on a slight upwards slope to roughly elevation 710 md (Elev. 670 MSL) at their southerly limits with the Dale No. 4 gangway being slightly lower than the Dale No. 7. The depth of the gangways below the ground surface ranged from 240 feet to 270 feet.

The method of mining in the Dale No. 1 mine was essentially the chute and pillar method. In this method, narrow chutes, at about 50-foot centers, were driven up the dip of the seam from the gangway to the chain pillar which was left to support the surface. It appears that 15 to 20 feet of chain pillar were left between the surface and the workings. At a number of locations, the chutes were driven to the surface both for ventilation and to permit dropping timbers into the mine. Cross-cuts or small drifts were driven at intervals between the chutes for ventilation leaving blocks or pillars of coal. The pillars were then extracted on the retreat starting at the far limits of the mine and at the top blocks and progressing downward to the gangway and outward toward the portal. Timber posts were installed at intervals to temporarily support the roof until mining was completed in specific areas. It is reported that about a 4-foot thickness of the Dale No. 4 seam was mined and some 6 feet of the Dale No. 7 seam. The old mine map indicates that the Dale No. 7 seam was mined first and then the Dale No. 4 seam was worked. The mining from Dale No. 1 was apparently completed by 1933. Reportedly, concrete bulkheads were constructed as seals in the Dale No. 7 gangway near the entry cross-cut from the Dale No. 4 seam. The effectiveness of these seals is, of course, unknown to us.

From 1945 to 1948, mining was resumed on the Dale No. 7 seam by the Andersen Coal Company. A slope drift was driven from the surface down the seam to the old gangway level and the Dale No. 7 seam mined on around the southerly limb of the syncline. Mining was apparently carried out by the chute and pillar method using the slope drift as the portal. Based on the reported production tonnage of 29,000 tons, the seam location, and geologic maps, the estimated extent of the Andersen Mine Company workings is shown on Plate 4.

Using the Dale No. 1 mine map, calculations indicate that the mined underground volume during the initial mining phase was approximately 72,000 cubic yards for the Dale No. 4 seam and the water level (entry) drift and about 110,000 cubic yards for the Dale No. 7 seam. An additional 27,000± cubic yards were mined on the Dale No. 7 seam by the Andersen Coal Company giving a total underground mined volume of 209,000± cubic yards. This roughly checks the reported combined production tonnage of 263,000 tons (240,000 cubic yards).

Around 1946-1950, the Dale No. 4 coal seam was mined from the surface as a strip mine operation over a length of approximately 1,800 feet of the seam at its surface outcrop. During the stripping operation, what is believed to have been chutes from the underground workings reportedly were encountered in the southerly part of the Dale Strip Pit. It is understood that these chutes were open when first exposed but later caved, at least to some extent. Mine wastes were believed to have been deposited into the openings that remained but, insofar as could be determined, no specific attempt was made to fill them completely for the full depth. That is, material apparently was deposited into the openings to whatever degree was needed to fill them up to the bottom of the pit.

The dimensions of the Dale Strip Pit are not accurately known at this time. However, Bonneville Power Administration drawings at the transmission line crossing near its mid-point indicate the pit is some 140 feet wide at the surface and at least 40 feet deep with sloping sides. Water stands in the northerly two-thirds of the pit (at least 10 feet deep at one point) with a pit width at the water surface of some 65 feet. The southerly third is dry, at least in the summer months, with the exposed bottom some 40 feet below the adjacent ground surface. Using these dimensions, the volume above the water surface is estimated at some 250,000 cubic yards. The volume below the water surface is unknown, but may be around 20,000 cubic yards.

The inferred centerline location and extent of the Dale Strip Pit relative to the underground workings are shown on Plate 4. Apparently some minor strip mining also was carried out along the Dale No. 7 seam over the Andersen Coal Company workings. A production of 4,100 tons (3,800 cubic yards) was reported for this operation. A shallow trench is visible for several hundred feet near the Andersen mine portal. However, because of its small volume, the location is not delineated on the attached plates.

At the present time, the quartz-rich weathered sandstone beds of the Puget Group are being mined for silica sand approximately 1,000 feet west of the Dale Strip Pit. The mining is being carried out by side-hill excavation of the west flank of the hill exposing a 70- to 80-foot high near-vertical face extending from roughly elevation 800 MSL to about elevation 720 MSL.

McKay Seam

The most extensive coal mining in Section 1 was carried out on the McKay seam which lies about 1,000 feet stratigraphically below the Dale No. 7 seam or some 1,300 feet horizontally to the east. Also dipping an average of 50^{o} to 60^{o} on the syncline limbs, the McKay seam reportedly varied from 10 feet to 25 feet in thickness. Underground mining was carried out at various times and under various ownerships from 1905 to as late as 1949.

Initially worked from a somewhat complex water-level drift system at the east flank of the hill until the coal was mined out above that level (elevation 740 to 750 md), the mine was converted to a slope drift mine in order to extract the coal deeper on the seam. Gangways were driven horizontally out along the seam at various levels from the slope drift(s) with the lowest, or 5th level gangway, at elevation -338 md. The coal was mined by the chute and pillar method with substantially all the coal extracted down the seam from the chain pillars at the surface to a depth of some 1,200 feet. Ground water encountered in the workings was drained by gravity along the gangways to the slope drift and then was pumped up to the water-level drift system to drain by gravity out that entry.

The projected horizontal limits of the underground workings on the McKay seam are shown on Plate 4. The mined thickness of the seam varied, but assuming an average thickness of 10 feet and using the mine map of these underground workings, calculations indicate an underground mined volume of 2,700,000 cubic yards.

This approximates the identifiable production tonnage of 2,700,000 tons (2,500,000 cubic yards).

Between about 1946 and 1954, the McKay seam was strip mined from the surface along its outcrop for some 1,100 feet on the north limb of the syncline (McKay Strip Pit 6) and about 1,800 feet on the south limb (McKay Strip Pit 7). Underground workings and/or chutes reportedly were encountered during the strip mining operation. The dimensions of the strip pits have not been determined but it is estimated that McKay Strip Pit 7 has a volume of at least 75,000 to 100,000 cubic yards and McKay Strip Pit 6 has a volume possibly in excess of 200,000 cubic yards.

SUBSURFACE HYDROLOGY

The evaluation of the hydrologic or ground water conditions underlying the vicinity of the Dale Strip Pit is complicated by the underground mine workings. It is understood that drainage from the workings continued to flow from the open Dale Mine portal following cessation of mining. Several years ago, the portal was blocked off by filling in a short length of the Dale entry tunnel at the entrance. At that time an 18-inch culvert was installed through the blocked portal to permit mine drainage to continue. The slope of the culvert is unknown but assuming it is the same as the entry tunnel slope, the culvert would have a capacity when flowing full of about 2,100 gallons per minute (gpm). However, staining in the culvert indicates a probable flow of 700 gpm to 1,100 gpm in the past.

In early March of this year, it was reported that ground water was flowing from a subsidence pit higher on the hill over the location of the Dale entry tunnel - some 350 feet southeast of the portal. It was estimated by others that this ground water flow from the pit, which is 77 feet higher than the culvert, was on the order of 800 gpm. It was also reported that the flow of water from the portal culvert appeared less than what formerly flowed and was estimated by us at about 300 gpm. The ground water flow at the pit had decreased to about 100 gpm by May and by mid-July the subsidence pit was dry. It is probable that recent caving occurred someplace in the underground workings which, combined with a partial blocking of the portal culvert, developed sufficient head to cause a breakout at the subsidence pit.

As discussed previously, the northerly two-thirds of the Dale Strip Pit contains ponded water throughout the year which is retained by a small berm or dam formed from mine waste or slough from the pit sides. The southerly third of the pit is dry during the summer months but strand lines indicate that water has previously ponded in that part of the pit also. Following heavy rainfall, the northerly pond in early March was overflowing the dam at a reported 50 gpm into several lower pond(s) or depression(s) formed by irregular mounds of earth in the southerly part of the Dale Strip Pit. This water in turn was retained by a wider berm which appears to have been left unexcavated during the strip mining. Located some 200 feet north of the south end of the Dale Strip Pit, this berm appears to coincide with the location of an old timber chute shown on the Dale Mine map. By March 20th, the lower pond had reportedly drained dry, although no outlet was visible in the pond bottom. Water also was ponded south of the wide berm. Visibly supplied by direct runoff from the adjacent roadway bordering the Strip Pit, the water level in this most southerly pond had dropped only slightly by March 20th.

During this period the Municipality began obtaining water quality data, including chemical analyses, from the two southerly ponds in the Dale Strip Pit as well as the flowing subsidence pit and the culvert at the Dale Mine portal. On March 14th, it is understood that dye was introduced into the two southerly ponds and subsequent monitoring gave no indication of dye appearing at any other location in the area. On March 21st, it was reported that dye was again introduced and approximately 200,000 gallons of water from the northerly pond was released into the south part of the strip pit which filled to a depth of six feet in five hours. We understand that this water had substantially drained the next morning. We also understand that no visible increase in flow or dye was noted at the subsidence pit or the portal culvert on March 21st.

On March 28th, water was again released, salt introduced into the southerly part of the Dale Strip Pit and monitoring for conductivity, fluorescence and chloride content performed until May 5th at the two southerly ponds, the portal culvert, the subsidence pit and a small stream flowing from an exposed coal seam high in the silica sand pit in the west flank of the hill. Except for continuous automatic conductivity monitoring the first nine days at the subsidence pit, all parameters and locations were monitored periodically commencing six to nine days after salt introduction with intervals between sampling ranging from one to nine days. On April 29th (32 days), increased conductivity and chloride content were observed in the stream with a subsequent decline in both parameters at the next and final sampling on May 5th. It was reported that no distinct increase in these parameters was observed at the other locations.

On the basis of these data and observations, it was concluded that the source of the water in the most southerly pond at the south end of the Dale Strip Pit was surface runoff from the adjacent ground. Samples from the overflow pond in the Dale Strip Pit, the flowing subsidence pit and the portal culvert were determined to be relatively similar in physical and chemical characteristics, and it was concluded that the water at the three locations had a common source or has been in contact with similar bedrock material. We concur in these conclusions and further conclude that the water in the north 2/3 of the Dale Strip Pit probably is ponded ground water.

Considering the relation of the Dale Strip Pit to the underground workings, we also believe that the overflow from the northerly pond into the southerly end of the Dale Strip Pit drains down an old chute into the underground workings on the Dale No. 4 seam and out the Dale Mine portal culvert. While it is possible that the dye or salt tracers could have been filtered out during flow to the chute through the pond bottom and/or the base of the wide berm, it is more likely that these tracers were diluted below detectable limits by ground water in the workings. It is estimated that the Dale No. 4 workings could have contained at least 2,000,000 gallons of ground water at that time between the south end of the Dale Strip Pit and the mine portal. While test borings and/or test wells were authorized, it was felt that they would not provide sufficient positive information beyond that already available, particularly since adequate location data of necessary accuracy was unobtainable as to position of the underground gangway. Therefore, drilling explorations were deferred until project requirements were more definitive.

After the Municipality's water quality monitoring studies, the operators of the silica sand quarrying operation bulldozed relatively shallow prospect trenches into bedrock at various locations on the westerly hillside. Seepage was observed in several of the prospects and four of the trenches were examined in detail by our geologist during the dry period in mid-July. The seepage was traced back to its origin and, in each trench, was observed to be issuing from a single isolated location in the bedrock. At each location, the flow was small, 1 gpm or less. It was determined by survey that the seepage locations on the hillside ranged from 160 feet to 230 feet above the portal culvert. The water surface of the pond in the northerly end of the Dale Strip Pit was 240 feet higher than the culvert and the exposed southerly pond bottom was 228 feet higher.

On the basis of present evidence, we believe that the ground water level or piezometric head in the unmined areas is located at a relatively shallow depth below ground surface and generally follows the surface topography as to elevation. While exceptions can be anticipated, the quantity of ground water, where encountered, would be relatively small and possibly isolated. This is supported by the prospect pits, the lack of visible springs along the hillside and the localized seepage from the exposed face of the silica sand quarry. The ground water can reasonably be expected to more likely travel along or parallel to the bedding planes rather than across the steeply dipping beds where unfractured.

The underground workings may drain relatively restricted areas, primarily parallel to the strike of the beds and the workings. This is supported by the report that the sealed portal of the Andersen mine on the Dale No. 7 seam opened, apparently in March, due to unknown causes. Reportedly, the slope drift was sounded to a depth of 100± feet (elevation 810 MSL) without encountering water.

DISCUSSION

The utilization of the Dale Strip Pit for the disposal of digested sludge involves two primary considerations: (1) the possibility of leachates draining from the pit into the underground workings and thus out the Dale Mine portal and, (2) the possibility of leachates entering the natural ground water.

The south 300 feet to 400 feet of the Dale Strip Pit are underlain directly by the underground workings on the Dale No. 4 seam. As discussed above, it is our opinion that at least part of this end of the pit drains directly into the workings through one or more chutes which were encountered in the strip mining operation. Because of the uncertain method and degree of backfilling the chutes, it is doubtful that an effective sealing of the pond bottom could be assured through the duration of the project. In view of this, the possibility of leachates draining into the workings and out the Dale Mine portal could not be eliminated on the basis of present information. For this reason, it is assumed that the use of this end of the pit would be unacceptable.

Beneath the remainder or northerly part of the Dale Strip Pit, the Dale mine map indicates that only the gangway was mined on the Dale No. 4 seam. All presently available information indicates that no chutes or passageways to the surface underlie this portion of the strip pit. The northerly two-thirds of the strip pit contains what we conclude to be ponded ground water. Definitive information is not available as to the fluctuation of the water surface during the summer months, but it has been reported to be moderate. As far as could be determined visually, no seepage flows from the northerly pond beneath its dam into the lower southerly pond during dry periods. While this does not eliminate the possibility of leachate draining into the Dale No. 4 seam workings, it would appear to reduce it.

Little information has been reported on the surface subsidence due to underground mining in Washington. However, the information which is available indicates that mined, steeply-dipping seams similar to the Dale and McKay seams generally cave soon after mining with the subsidence confined roughly between the surface limits of the seam outcrop and vertical projection of the seam depth of about 200 feet. Because of the proximity of the Dale No. 7 workings to the Dale Strip Pit, surface subsidence due to that seam could approach the pit. Evidence of this has not been detected; however, it could be masked by the heavy undergrowth bordering the east side of the Dale Strip Pit. Fracturing has not been observed in the east pit wall where such evidence could be reasonably expected if subsidence had occurred.

The actual condition of the bottom of the northerly two-thirds of the Dale Strip Pit is, of course, unknown. However, in view of the reported relatively stable water surface during dry periods, it is probable that a one to two-foot thick compacted impervious clay blanket on the bottom and the pit sides would be adequate to prevent leachates from draining out of the strip pit into the workings or from entering the ground water provided subsidence has not occurred. An engineered impervious embankment should replace the existing berm retaining the south end of the ponded ground water.

Prior to finally selecting the Dale Strip Pit for a sludge disposal site, consideration should be given to draining the pit to enable the submerged bottom and sides to be examined. The configuration and depth of the strip pit below the pond surface is not known. As mentioned previously, the pit is at least 10 feet deep at one point. If uniform in cross-section throughout its length, the northerly two-thirds of the strip pit could contain 4,000,000 gallons of water or more. In view of this, we strongly advise that this quantity of water not be discharged into the southerly end of the strip pit. The condition of the underground workings is unknown after the breakout at the subsidence pit near the mine portal. Therefore, the effect of discharging 4,000,000 gallons of water through the workings cannot be predicted.

Draining the north part of the strip pit would also permit evaluation of the possibility that ground water is flowing into the strip pit rather than out of it. In that event, sealing against inflow would be necessary since the sludge could not be deposited into the water. In the event that sealing is required, a much thicker blanket would be needed to counteract the hydrostatic pressure. This would, of course, reduce the usuable volume of the strip pit.

While the alternate sites, McKay Strip Pit 6 and McKay Strip Pit 7, were not investigated to the same degree, we believe that utilization of these sites would involve similar considerations. It appears that the underground workings on the McKay seam were extensive beneath the strip pit locations; thus the possibility of leachate drainage into the workings could be greater than at the Dale Strip Pit. However, in view of the complex mine drainage system, considerably greater dilution of any leachate would seem likely, if in fact, drainage is still issuing from the McKay Mine. Further investigation of McKay Strip Pit 6 and McKay Strip Pit 7 would be needed to resolve these concerns.

Attachments: Selected Bibliography
Plate 1
Plate 2
Plate 3
Plate 4

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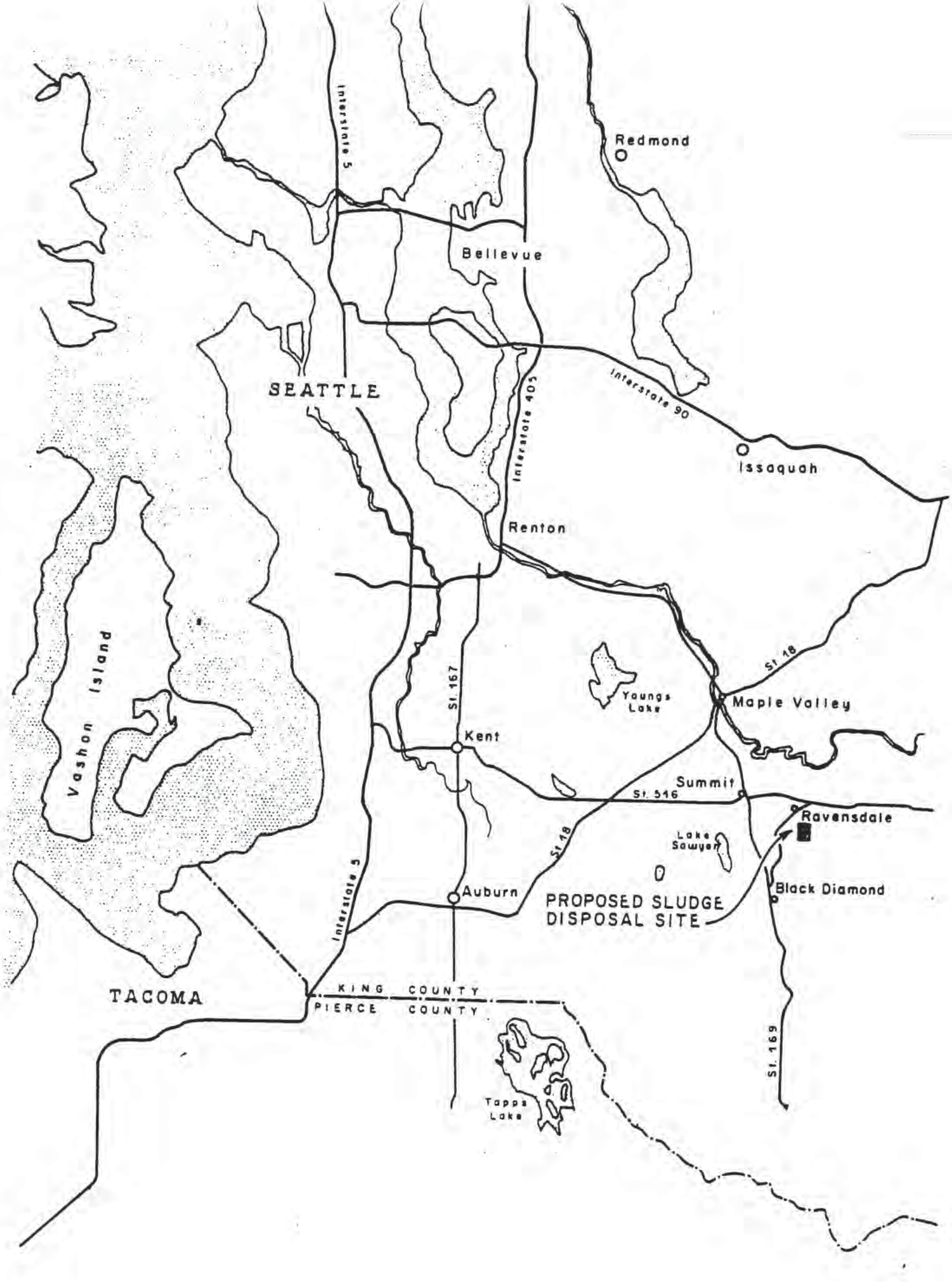
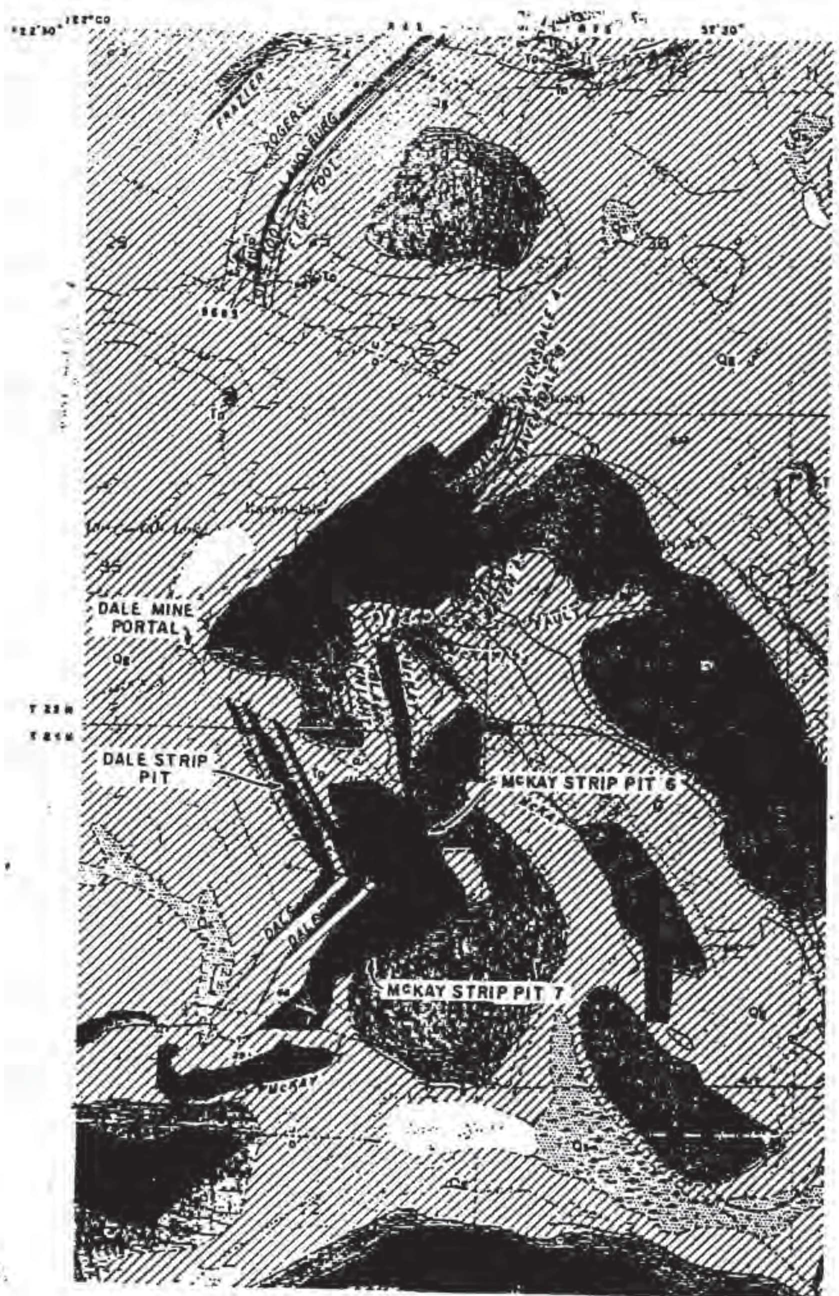

Redmond
Interstate 5
Bellevue
SEATTLE
Interstate 90
Interstate 405
Issaquah
Renton
Vashon Island
St. 167
St. 18
Youngs Lake
Maple Valley
Kent
Summit
St. 516
Ravensdale
Lake Sawyer
St 18
Black Diamond
Auburn
PROPOSED SLUDGE
DISPOSAL SITE
Interstate 5
TACOMA
KING COUNTY
PIERCE COUNTY
St. 169
Tapps Lake

PLATE 1

DALE STRIP PIT
McKAY STRIP PIT 6
McKAY STRIP PIT 7
CEDAR RIVER
Summit
Georgetown
Ravensdale
Ravensdale Lake
Retreat Lake
Lake Sawyer
COUNTY PARK
Lake No 12
Ginder Lake
Sawmill
Trailer Park
Coal Mine
Substation
Borrow Pit
PACIFIC

PLATE 2



Pleistocene

Qg

Glacial drift

Stratified outwash gravel, sand, silt and clay, and till composed of unsorted clay, sand, cobbles and boulders. Contains some mudflow material

Eocene

Puget Group

Arkosic and feldspathic, micaceous sandstone, siltstone, claystone, carbonaceous shale, and coal.

Tpv, *conglomerate composed of basic igneous rocks*

Contact, approximately located

Short dashed where inferred; dotted where concealed

McKAY

Coal bed approximately located

Showing outcrop or trace projected to surface from other data; short dashed where inferred; dotted where concealed; queried where uncertain. Name or number refers to coal bed

U D

Fault, approximately located

Short dashed where inferred; dotted where concealed; queried where uncertain. U, upthrown side; D, downthrown side; arrows indicate direction of lateral movement. A, relative movement away from observer; T, toward observer (used only in structure sections)

Anticline

Showing trace of axial plane and bearing and plunge of axis. Dashed where approximately located; short dashed where inferred; dotted where concealed

Syncline

Showing trace of axial plane and bearing and plunge of axis. Dashed where approximately located; short dashed where inferred; dotted where concealed

Strike and dip of beds

Strike and dip of beds in mine workings

Mined areas

1 ½ 0 1 MILE

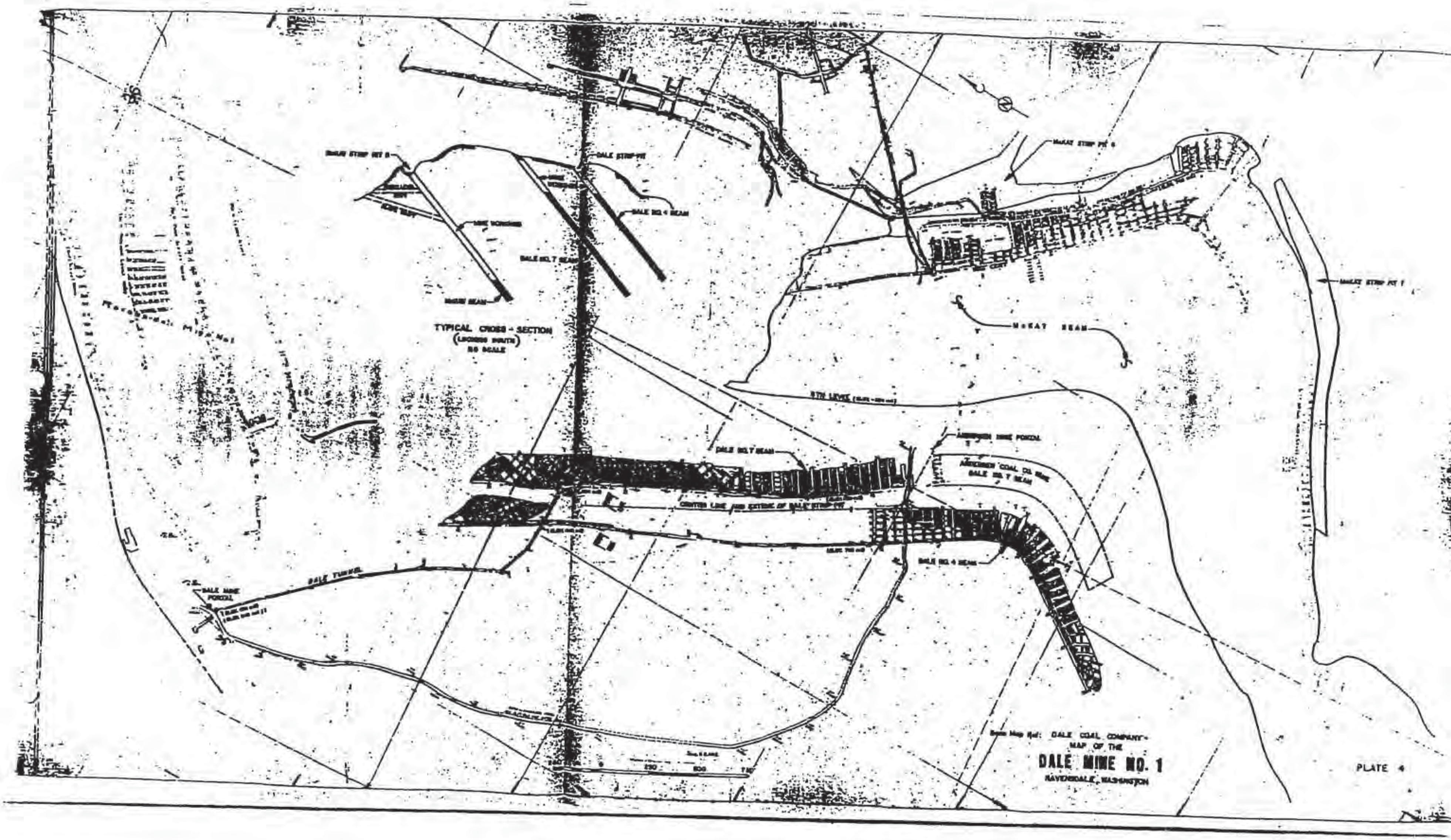
SCALE 1:24 000

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

1963

APPROXIMATE MEAN DECLINATION, 1963

PLATE 3


TYPICAL CROSS - SECTION
DALE STRIP PIT
DALE NO. 4 SEAM
DALE NO. 7 SEAM
McKAY SEAM
DALE NO. 7 SEAM
CENTER LINE AND EXTENT OF DALE STRIP PIT
DALE NO. 4 SEAM
DALE TUNNEL
DALE MINE PORTAL
DALE COAL COMPANY
MAP OF THE
DALE MINE NO. 1
RAVENSDALE, WASHINGTON
PLATE 4